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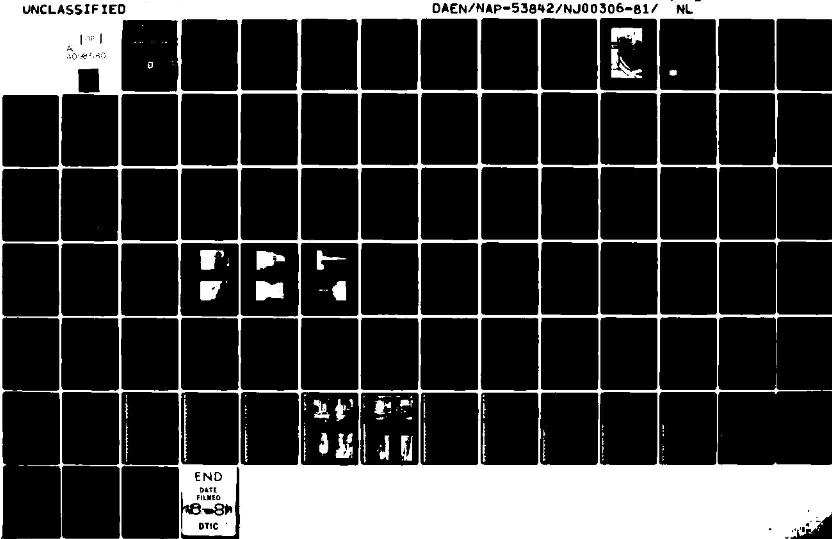

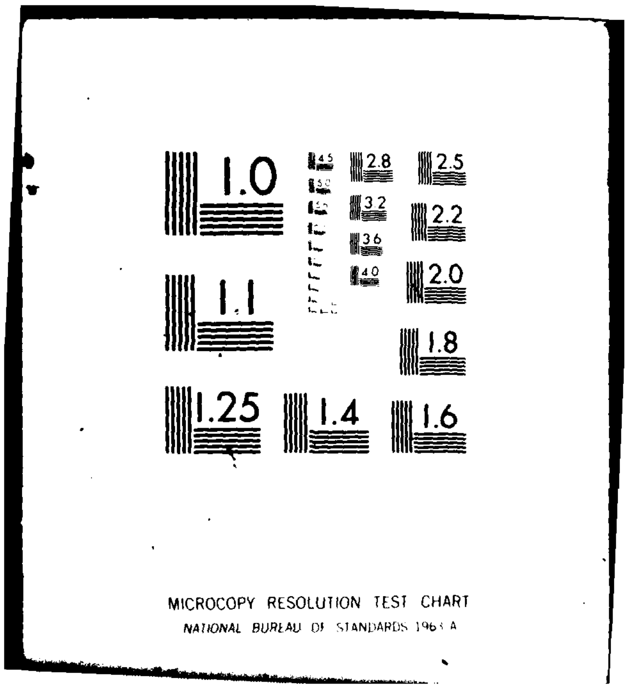
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HUDSON RIVER BASIN
TRIBUTARY OF WALLKILL RIVER
SUSSEX COUNTY
NEW JERSEY

MORRIS LAKE DAM
NJ 00306

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY

Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

Rept. no. DAEN/NAP-53842/NJ00306-81/03

MARCH 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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4. TITLE (and Subtitle) Phase I Inspection Report National Dam Safety Program Morris Lake Dam (NJ00306) Sussex County, NJ		5. TYPE OF REPORT & PERIOD COVERED FINAL
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9. PERFORMING ORGANIZATION NAME AND ADDRESS Langan Engineering Associates, Inc. 990 Clifton Ave. Clifton, N.J. 07013		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS NJ Department of Environmental Protection Division of Water Resources P.O. Box CN029 Trenton, NJ 08625		12. REPORT DATE March 1981 13. NUMBER OF PAGES 65
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Approved for public release; distribution unlimited.

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18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams
Embankments
Visual Inspection
Structural Analysis
National Dam Safety Program
Morris Lake Dam, N.J.
Spillways
Seepage

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

24 APR 1981

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Morris Lake Dam in Sussex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Morris Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate because a flow equivalent to 51 percent of the Probable Maximum Flood would cause the dam to be overtopped. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Within three months of the consultant's findings, remedial measures to ensure spillway adequacy should be initiated.

b. The following remedial actions should be initiated within three months from the date of approval of this report:

(1) Perform additional investigation to determine seepage conditions through and under the dam, the engineering properties of the dam and foundation, and whether or not conventional safety margins exist under more severe stress conditions than those observed during our inspection, and, what modifications may be required to achieve such safety margins.

(2) Provide emergency low level outlets for the dam.

(3) Repair areas of spalled and deteriorated concrete on the dam appurtenances.

(4) Investigate the cause of cracking and separation and repair the facing on the downstream side of the dam.

NAPEN-N

Honorable Brendan T. Byrne

c. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

d. An emergency action plan should be developed which outlines actions to be taken by the owner to minimize the downstream effects of an emergency at the dam within three months from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Courter of the Thirteenth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

MORRIS LAKE DAM (NJ00306)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 12 September and 1 December 1980 by Langan Engineering Associates, Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Morris Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate because a flow equivalent to 51 percent of the Probable Maximum Flood would cause the dam to be overtopped. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Within three months of the consultant's findings, remedial measures to ensure spillway adequacy should be initiated.

b. The following remedial actions should be initiated within three months from the date of approval of this report:

(1) Perform additional investigation to determine seepage conditions through and under the dam, the engineering properties of the dam and foundation, and whether or not conventional safety margins exist under more severe stress conditions than those observed during our inspection, and, what modifications may be required to achieve such safety margins.

(2) Provide emergency low level outlets for the dam.

(3) Repair areas of spalled and deteriorated concrete on the dam appurtenances.

(4) Investigate the cause of cracking and separation and repair the facing on the downstream side of the dam.

c. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

d. An emergency action plan should be developed which outlines actions to be taken by the owner to minimize the downstream effects of an emergency at the dam within three months from the date of approval of this report.

APPROVED: James G. Ton
JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 21 April 1981

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

NAME OF DAM:	MORRIS LAKE DAM
ID NUMBER:	FED ID No NJ 00306
STATE LOCATED:	NEW JERSEY
COUNTY LOCATED:	SUSSEX
STREAM:	TRIBUTARY OF WALLKILL RIVER
RIVER BASIN:	HUDSON
DATE OF INSPECTION:	SEPTEMBER & DECEMBER 1980

ASSESSMENT OF GENERAL CONDITIONS

Morris Lake dam, classified under high hazard potential category, is in fair overall condition. The structural stability of the dam is uncertain. The concrete gunite facing on the downstream face of the dam has numerous large cracks and is separating from the dam in areas. There is seepage through one of the cracks. Spalling and deteriorating concrete exist at a number of locations on the upstream and downstream face of the dam, and are particularly severe at the east upstream abutment and on the spillway wingwall near the west abutment. The condition of the original masonry dam within the present dam is unknown. There is no emergency low level outlet for the dam. There is no engineering data available concerning the design or construction of the original dam or subsequent modifications. The spillway capacity as determined by the Corps of Engineers screening criteria is inadequate. The dam can adequately pass only 50% of the ~~PMF.~~ probable maximum flood,

The following are recommended to be done soon:

Perform additional investigation to determine seepage conditions through and under dam, the engineering properties of the dam and foundation, and whether or not conventional safety marigns exist under more severe stress conditions than those observed during our inspection, and, what modifications may be required to achieve such safety margins. Provide emergency low level outlet for the dam. Repair areas of spalled and deteriorated concrete on the dam appurtenances.

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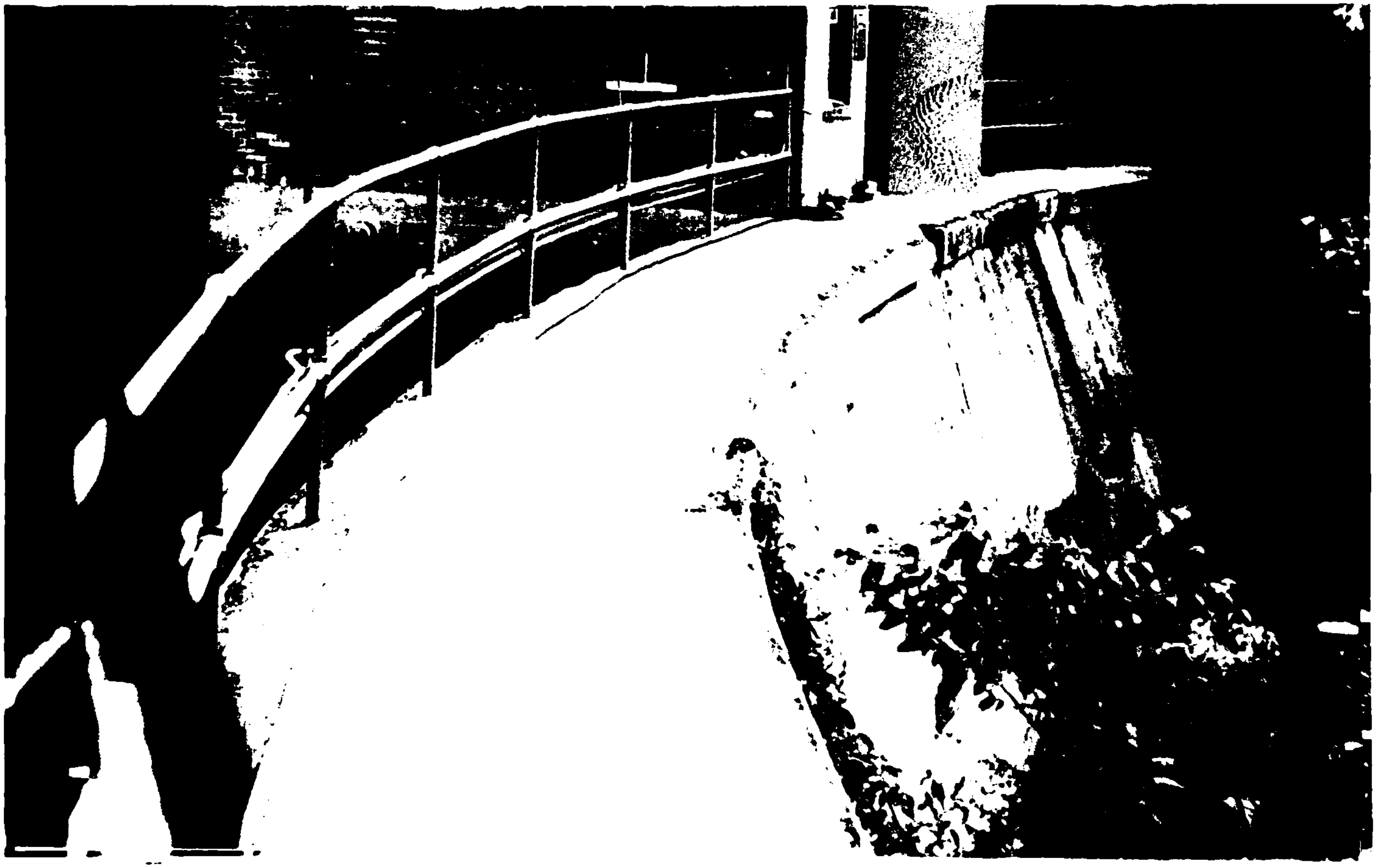
Rept. no. DAEN/NAP -53842/NJ 00306 -81/03

The following are recommended to be done in the near future:

Investigate the cause of cracking and separation and repair the facing on the downstream side of the dam. Establish a warning system and develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam. The spillway capacity is estimated to be inadequate. The capacity of the spillway and SDF should be determined using more precise and sophisticated methods and procedures.

K. Peter Yu, P.E.



OVERALL VIEW
MORRIS LAKE DAM

12 September 1980

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

NAME OF DAM:	MORRIS LAKE DAM
ID NUMBER:	FED ID No NJ 00306
STATE LOCATED:	NEW JERSEY
COUNTY LOCATED:	SUSSEX
STREAM:	TRIBUTARY OF WALLKILL RIVER
RIVER BASIN:	HUDSON
DATE OF INSPECTION:	SEPTEMBER & DECEMBER 1980

LANGAN ENGINEERING ASSOCIATES, INC.

Consulting Civil Engineers
990 CLIFTON AVENUE
CLIFTON, NEW JERSEY
201-472-9366

CONTENTS

NATIONAL DAM SAFETY REPORT

MORRIS LAKE DAM FED ID NO NJ 00306

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

SECTION 1 PROJECT INFORMATION

1.1 General

Authority to perform the Phase I Safety Inspection of Morris Lake Dam was received from the State of New Jersey Department of Environmental Protection, Division of Water Resources by letter dated 12 August 1980. This Authority was given pursuant to the National Dam Inspection Act, Public Law 92-367 and by agreement between the State and the US Army Engineers District, Philadelphia.

The purpose of the Phase I Investigation is to develop an assessment of the general conditions with respect to safety of Morris Lake Dam and appurtenances based upon available data and visual inspection, and determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted. The assessment is made using screening criteria established in Recommended Guidelines for Safety Inspection of Dams prepared by the Department of Army, Office of the Chief of Engineers. It is not the purpose of the inspection report to imply that a dam meeting or failing to meet the screening criteria is, per se, certainly adequate or inadequate.

1.2 Project Description

a. Description of Dam and Appurtenances

Morris Lake Dam is a concrete faced stone masonry gravity structure with an overall length of dam and appurtances of approximately 205 feet and an effective length of 160 feet. The dam is reported to have a vertical upstream face and a 2 vertical to 1 horizontal downstream face. The main axis of the dam is slightly concave downstream and is oriented in a east-west direction separating the upstream Morris Lake and the downstream Glen Lake. Based on available information, the original dam was constructed of granitic rock. At a latter date the dam was raised several feet to its present level and the stone masonry dam was faced with an unknown thickness of reinforced concrete (gunite) on the upstream side and approximately 1 1/2 inches of unreinforced concrete on the downstream side. The top of the dam is approximately 5 feet wide. The dam is reported to have a maximum height of 38 feet and to be founded on the bedrock. The depths from top of dam to upstream and downstream lake bottom measured in the center of the dam are approximately 15 feet.

The spillway has a broad crested weir of trapezoidal cross section and it exists in the form of a rectangular opening near the west abutment of the dam. The opening measures approximately 2 feet high and 14 feet wide with the base located approximately 3.2 feet below the top of the dam. It is reported that stop logs have been used in the past to increase the storage elevation of the dam.

A gatehouse exists on the crest of the dam about 1/3 of its length from the east abutment.

There are presently two outlet pipes, of 12 inch and 16 inch diameter, existing through the dam below the gatehouse. Both pipes are water supply mains for the Town of Newton and a small portion of the Town of Sparta. Based on conversations with the dam's caretaker, the normal daily consumption rate is 800,000 gallons per day.

A more elaborate description of the water works for the reservoir is included in Appendix 4.

b. Location

Morris Lake Dam is located at the southern end of Morris Lake and the northern end of Glen Lake in Sparta, Sussex County, New Jersey. It is located at north latitude 41°02.6' and west longitude 74°36.5'. A regional vicinity map is given in Fig. 1.

c. Size Classification

The maximum storage capacity of Morris Lake Dam is estimated to be 2,985 ac ft. The dam is classified as intermediate in size based on this storage capacity which is more than 1,000 ac ft but less than 50,000 ac ft. The dam is classified as small based on its maximum height of 38 feet which is less than 40 feet. Accordingly the dam is classified as "Intermediate" in size.

d. Hazard Classification

Morris Lake Dam is listed as having a "High" Hazard potential on the National Inventory of Dams. The downstream potential damage centers of Sparta Glen, a recreation area, and the northern portion of the Town of Sparta are located approximately 1/2 and 1 1/2 miles from the dam. Based on visual inspection of the downstream area, a failure of Morris Lake Dam would result a surge of water into Glen Lake immediately downstream thus causing possible overtopping and failure of Glen Lake Dam, which in turn would result in flooding of Sparta Glen, and possibly the northern portion of Sparta. This represents a potential for more than a few loss of lives. Accordingly, it is recommended to keep the Hazard Potential Classification for Morris Lake Dam as "High".

e. Ownership

Ownership of Morris Lake Dam is by The Town of Newton, 39 Trinity Street, Newton, New Jersey.

f. Purpose of Dam

The purpose of the dam is public water supply for the Town of Newton and a small portion of the Town of Sparta.

g. Design and Construction History

Based on conversations with Town of Newton officials and published reports, the construction history of Morris Lake Dam is believed to be as follows:

The dam was originally constructed in 1894-1895 as a stone masonry dam for the purpose of water supply. The dam was engineered by Louis L. Tribus, of New York, New York and constructed by Smith and McCormick. In 1927, apparently due to seepage of water through the dam, the upstream face of the dam was covered with a thickness of up to one foot of reinforced concrete (reported to be gunite) and the downstream face with a 1 to 1 1/2 inch thick coating of unreinforced concrete.

At this time, the existing gatehouse was added and the dam raised several feet. Engineering for the Gatehouse was performed by William J. Hardin and construction was performed by John W. Heller, Co. In 1929 a new water intake was installed in the lake. Engineering for this new intake was by the firm of Tribus and Massa and constructed by Merritt, Chapman and Scott Corp., New York.

Also in this time period a 20 inch diversion pipeline was installed between the head gate at Pine Swamp Brook and Morris Lake which replaced a diversion channel constructed in 1895. This diversion pipe is used only during dry periods when the level of Morris Lake drops to the point of not adequately servicing the water needs of the Town of Newton. In 1976 a 16 inch water supply pipe was installed through a former 24 inch low level outlet, thereby eliminating an emergency low level outlet for the dam.

h. Normal Operational Procedures

Based on conversations with representatives of The Newton Department of Water, operational procedures are the following:

Chlorine and fluoride are added at the Gatehouse prior to the water entering the 12 and 16 inch water supply pipelines. Daily lake level readings are taken to depth of water below spillway. Daily records of water flow through the pipelines are maintained.

1.3 Pertinent Data

a. Drainage Areas

a. Drainage Areas	1.07 sq mi for Morris Lake under normal conditions. 3.5 sq. mi. when head gates at Pine Swamp Brook are opened during dry periods.

b. Discharge at Damsite

Maximum known flood at damsite	unknown
Ungated spillway capacity at max. pool elev.	283 cfs (Assumed top of dam.

c. Elevation (ft. above MSL)

Top of Dam	942.8
Maximum pool-design surcharge	unknown
Spillway crest	939.6
Streambed at centerline of dam	928±
Maximum tailwater	Unknown. Approx. el 930.8 at time of inspection

d. Reservoir

Length of maximum pool	Approx 3,450 ft
Length of normal pool	Approx 3,400 ft

e. Storage (acre-feet)

Normal pool	Approx 2,470 ac ft
Top of dam	Approx 2,985 ac ft

f. Reservoir Surface (acres)

Top dam	Approx 165
Maximum pool	Approx 165 (Assumes top of dam)
Normal pool	Approx 157 (Assumed to be spillway crest)
Spillway crest	Approx 157

g. Dam

Type	Concrete faced stone masonry gravity
Length	160 ft
Height	15 ft (top of dam to downstream streambed) 38 ft (top of dam to Bedrock)
Top Width	Approx 5 ft
Side Slopes	U/S vertical D/S 2V:1H

Zoning	Unknown
Impervious Core	Unknown
Cutoff	Foundation reported to be on bedrock
Grout curtain	None reported

h. Spillway

Type	Broad crested trapazoidal weir
Length of weir	14 ft
Crest elevation	939.6 ft MSL
Gates	None
U/S Channel	Vertical face
D/S Channel	1H to 2V

i. Regulating Outlets — 12" water supply main; 16" water supply main

SECTION 2 ENGINEERING DATA

2.1 Design

No engineering design data pertaining to engineering values, calculation or test results for the original structure or subsequent modifications have been found.

2.2 Construction

The available data pertaining to the construction and modifications of the dam and appurtenances known to exist and to be possessed by the town of Newton, New Jersey are:

Engineer's Final Report on Construction of the Newton, New Jersey Water Works dated November 30, 1895 by Louis L. Tribus.
Notes on Newton, New Jersey Water Works Construction and Litigation by Louis L. Tribus, New England Water Works Association, Vol XXIII, No. 2, June 1909, included in Appendix 4.
Survey, 20" Cast Iron Pipe Line in Morris Lake, Sussex County, New Jersey for Newton Water Works by Tribus and Massa, September 1929.

2.3 Operations

There is a full time resident at the dam. The resident reportedly makes daily visual examinations of the dam and appurtenances as part of his daily duties, together with his performance of items given in normal operational procedures.

2.4 Evaluation

Available information concerning the engineering properties of the dam and foundation materials and materials used in subsequent modifications is not adequate to evaluate the design and construction of the dam.

SECTION 3 VISUAL INSPECTION

Morris Lake Dam is in fair overall condition. The gunite facing on the downstream face of the dam has numerous large cracks. The gunite surface below the cracks appears to have separated from the body of the dam. Weeds are growing in many of these cracks. There is limited seepage from a crack in the gunite surface approx 10' below the top of the dam in the area of the gatehouse. There are bulges in the gunite surface on the downstream face at the water line. The upstream face of the dam, where visible, has occasional areas of spalling and cracking of the gunite surface. The concrete forming the east abutment is spalled and deteriorating on the upstream face. The concrete downstream wingwall on the west side of the spillway is extensively spalled and deteriorated.

The gatehouse appears in good general condition with all equipment reported in operable condition.

Conversations with a representative of the Newton Department of Water revealed the original 24 inch diameter low level outlet had been used as a sleeve for the installation of the 16-inch water main, thereby eliminating the low level outlet.

The reservoir is surrounded by forested watershed areas.

Immediately downstream of the dam is Glen Lake. Morris Lake Dam separates Morris Lake from Glen Lake.

SECTION 4 OPERATIONAL PROCEDURES

General operational procedures for the dam include daily recordings of water main flow, fluoridation and chlorination of water and periodic cleaning of the water supply intake screens. There is a full time resident of the Newton Department of Water living at the damsite.

No formal warning system is in effect.

SECTION 5 HYDRAULIC/HYDROLOGIC

The hydraulic/hydrologic evaluation is based on a Spillway Design Flood (SDF) equal to the probable maximum flood chosen in accordance with the evaluation guidelines for dams classified as high hazard and intermediate in size. Hydrologic design data for this dam was not available. The PMF has been determined by developing a synthetic hydrograph based on the probable maximum precipitation of 22.3 inches (200 sq. mi.-24 hour). The Corps of Engineers has recommended the use of the SCS triangular unit hydrograph with the curvilinear transformation. Hydrologic computations are presented in Appendix 3. The PMF inflow determined for the subject watershed is 4,533 cfs (routed to 1,545 cfs).

The capacity of the spillway at maximum pool elevation (942.8) is 283 cfs which is significantly less than the SDF. Flood routing indicates the dam will overtop by 1.92 ft for the PMF and will not overtop for the 1/2 PMF. We estimate the dam can adequately pass only 50% of the PMF.

The present outlet structures consist of one 12 inch CIP and one 16 inch RCP which deliver potable water to the town of Newton. No emergency low level outlet exists.

SECTION 6 STRUCTURAL STABILITY

Our visual observations indicate no evidence of immediate instability of the dam exist under normal operating conditions. However, the actual degree of stability is not certain. No information is available concerning the engineering properties of the foundation and dam materials. The stone masonry forming the original dam is not visible due to the gunite surfacing and its conditon is unknown. The gunite surfacing on the downstream face of the dam has numerous large cracks and appears to have separated from the dam in various areas. Seepage through cracks was observed during inspection.

No design data is available for the orignal dam or subsequent modifications made in 1927 and 1929.

Operating records pertain to daily flows through the 12 inch and 16 inch water supply pipelines only.

There is inadequate design and construction information to determine the actual degree of stability of the dam using present day state of the art methods.

Morris Lake dam is located in Seismic Zone I of the Seismic Zone map of Contiguous States. The degree of stability of the dam and appurtenances under static loading are uncertain with respect to conventional safety margins and may be unstable under earthquake loading. Its actual structural stability should be evaluated using state of the art methods when additional relevant information becomes available.

SECTION 7 ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment

Morris Lake dam is in fair overall condition. The structural stability of the dam is uncertain. The concrete gunite facing on the downstream face of the dam has numerous large cracks and is separating from the dam in areas. Seepage was observed through one of the cracks during inspection. Spalling and deteriorating concrete exist at a number of locations on the upstream and downstream face of the dam and are particularly severe at the east upstream abutment and on the spillway wingwall near the west abutment. The condition of the original masonry dam within the present dam is unknown. There is no emergency low level outlet for the dam. There is no engineering data available concerning the design or construction of the original dam or subsequent modifications. The spillway capacity as determined by the Corps of Engineers Screening criteria is inadequate. The spillway can adequately pass only 50% of the PMF.

7.2 Recommendations/Remedial Measures

The following are recommended to be done soon:

1. Perform additional investigation to determine seepage conditions through and under the dam, the engineering properties of the dam and foundation, and whether or not conventional safety margins exist under more severe stress conditions than those observed during our inspection, and, what modifications may be required to achieve such safety margins.

2. Provide emergency low level outlets for the dam.

3. Repair areas of spalled and deteriorated concrete on the dam appurtenances.

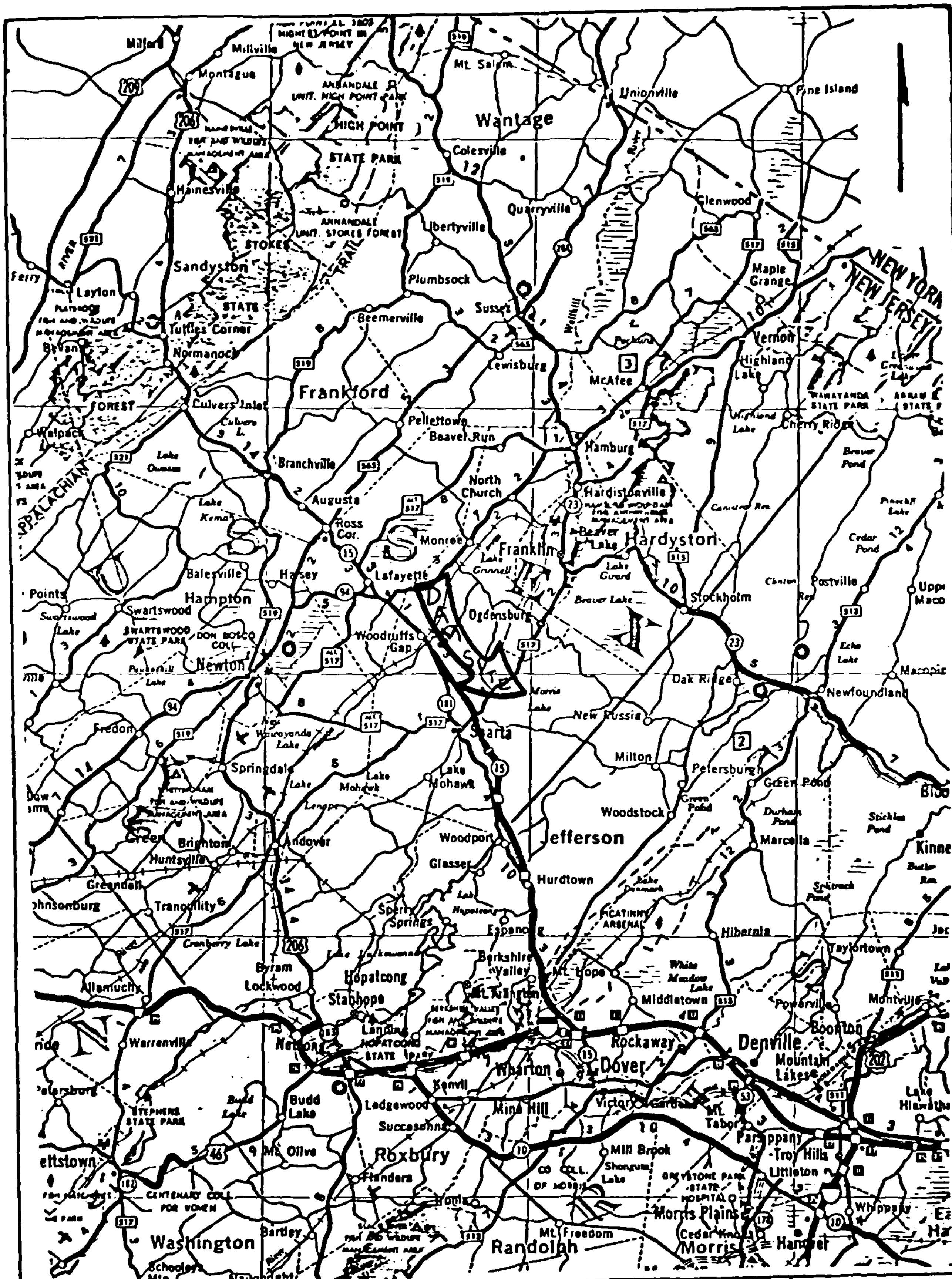
The following are recommended to be done in the near future:

1. Investigate the cause of cracking and separation and repair the facing on the downstream side of the dam.

2. Establish a warning system and develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

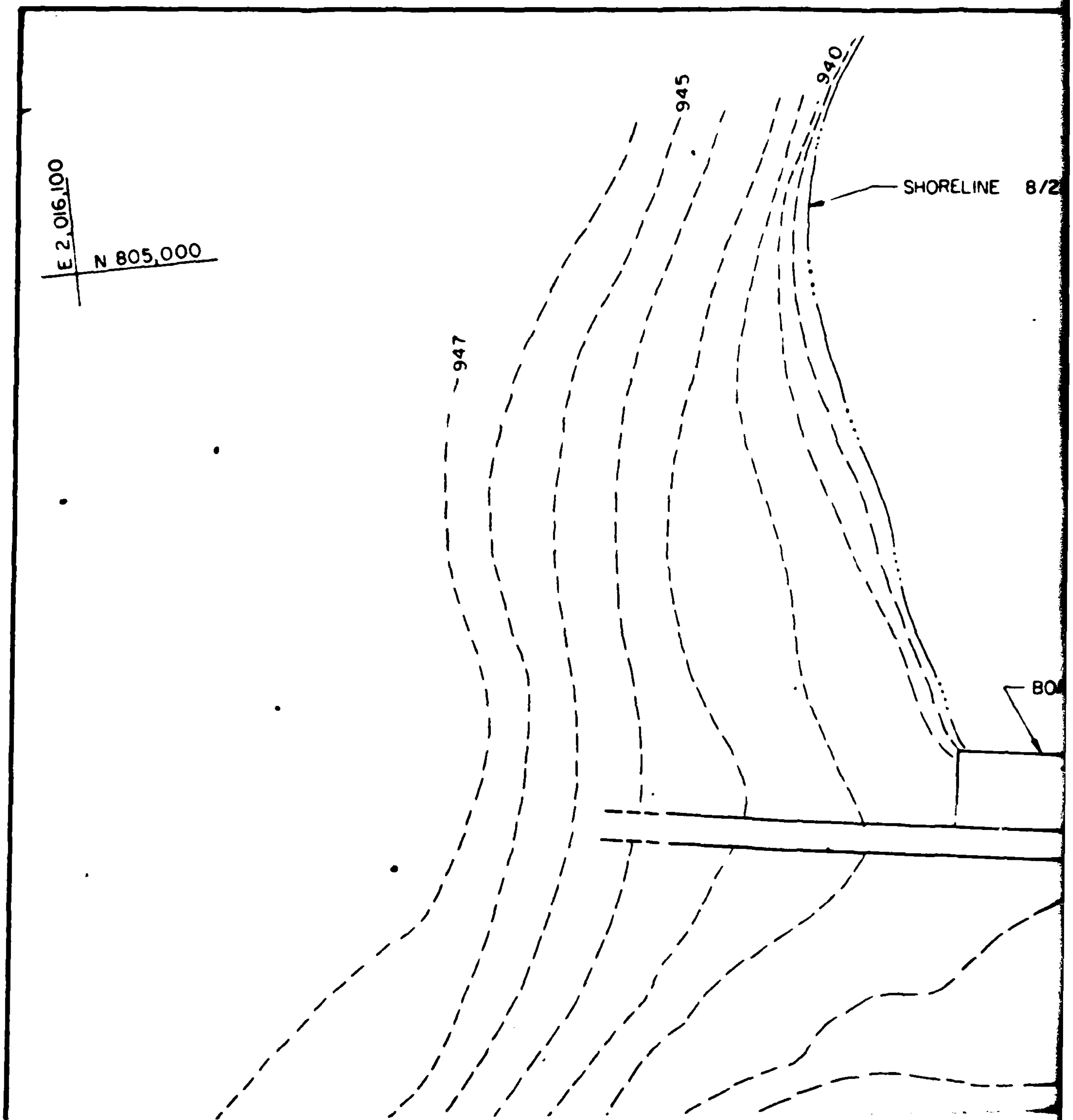
3. The spillway capacity is estimated to be inadequate. The capacity of the spillway and SDF should be determined using more precise and sophisticated methods and procedures.

FIGURES



BY ________ DATE ________ REGIONAL VICINITY MAP JOB NO. 80145

CKD. ________ DATE ________ MORRIS LAKE SCALE: 1" ± 2 miles FIG. No. 1



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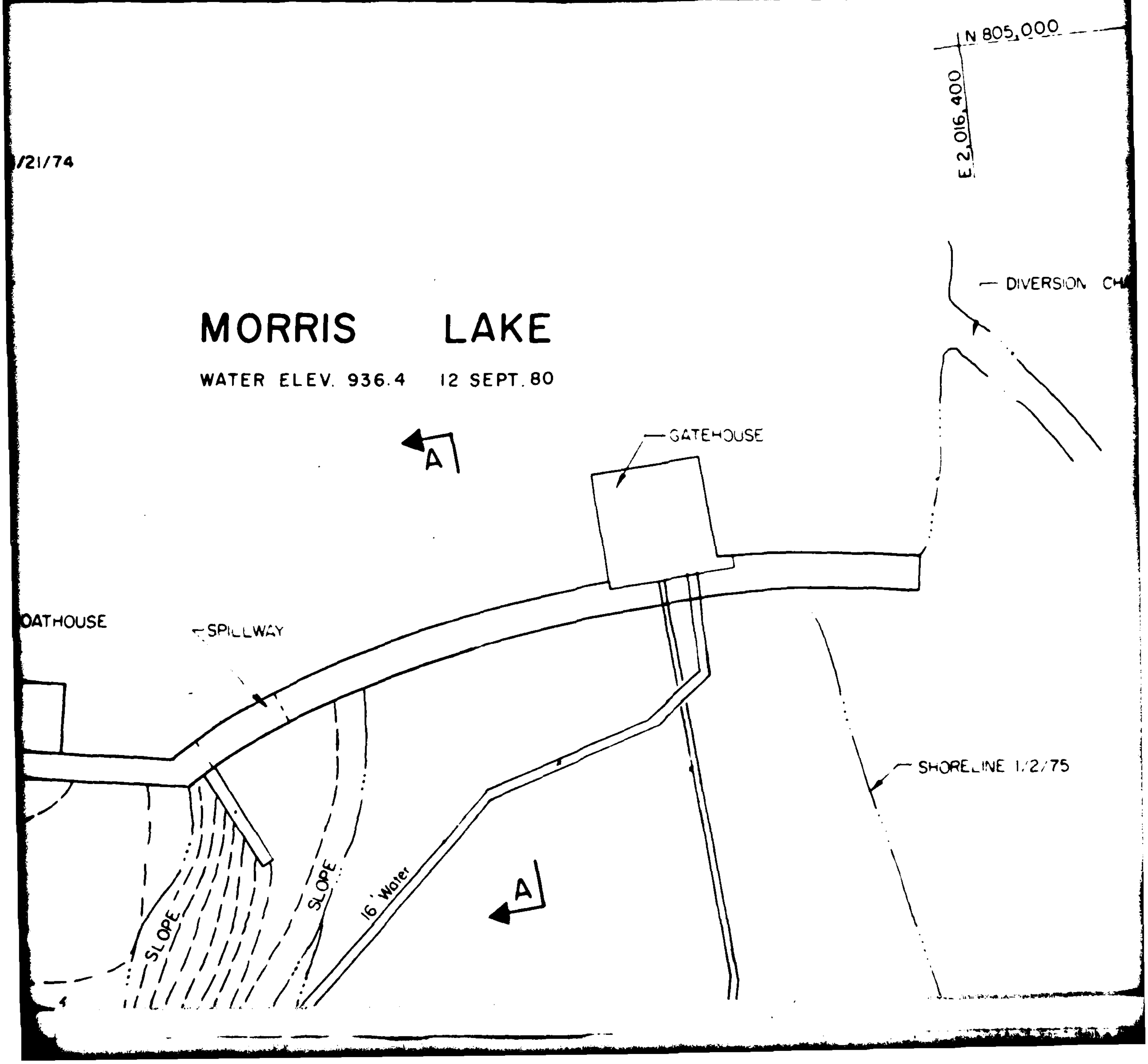

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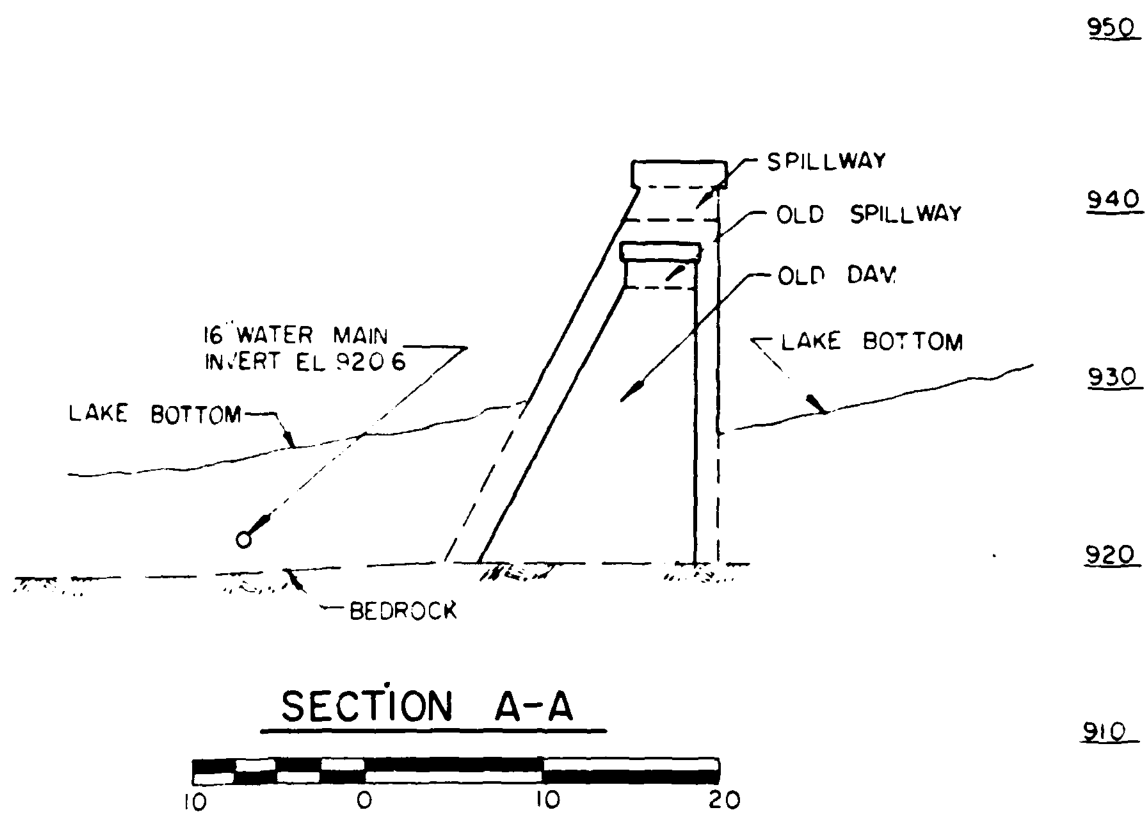
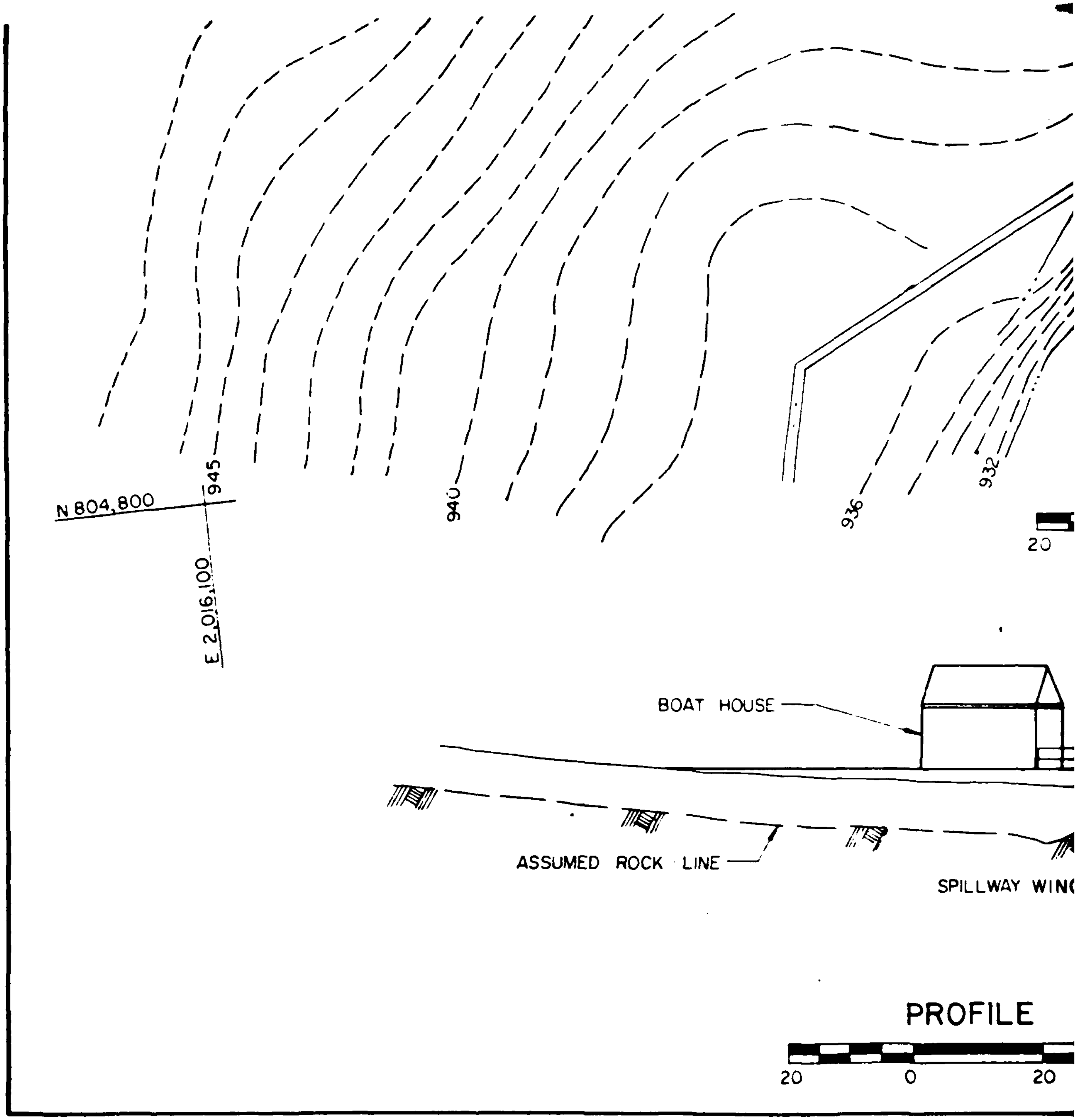


SECTION A-A

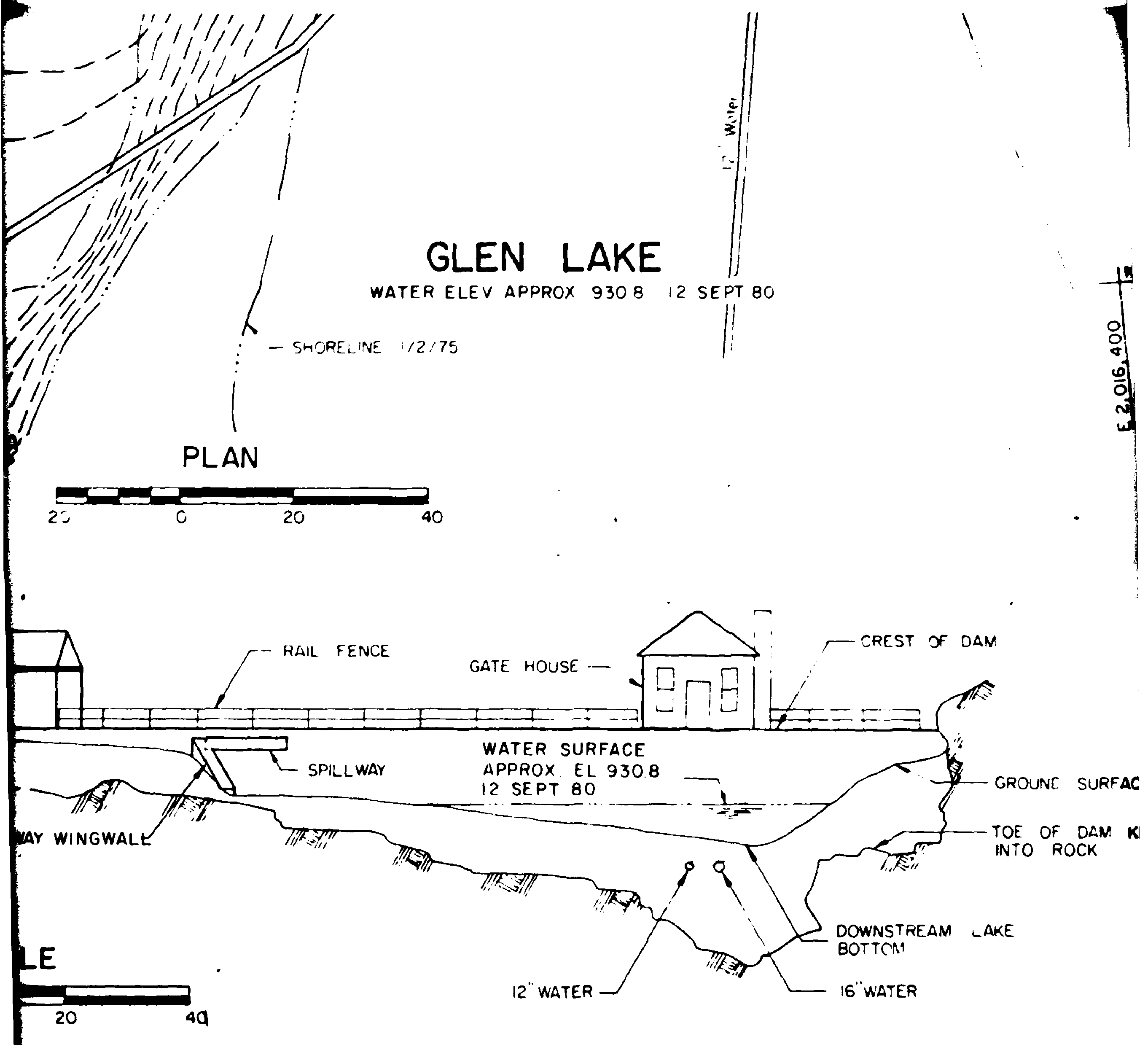
NOTES:

1. THIS PLAN WAS ADAPTED FROM DRAWING PREPARED BY CAHN ENGINEERS, INC., WALLINGFORD, CONNECTICUT, MORRIS LAKE DAM, DAM PLAN, PROFILE & SECTION, MARCH 1979



N 804,800
E 2,016,100
945
940
936
932
20
BOAT HOUSE
ASSUMED ROCK LINE
SPILLWAY WIN
PROFILE
20
0
20

4


12" Water
GLEN LAKE
WATER ELEV APPROX 930.8 12 SEPT 80
SHORELINE 1/2/75
E 2,016,400
PLAN
20
0
20
40
RAIL FENCE
GATE HOUSE
CREST OF DAM
SPILLWAY
WATER SURFACE
APPROX. EL 930.8
12 SEPT 80
GROUND SURFAC
WAY WINGWALL
TOE OF DAM K
INTO ROCK
DOWNSTREAM LAKE
BOTTOM
LE
20
40
12" WATER
16" WATER

2. THIS PLAN WAS COMPILED FROM RECORD DRAWINGS FOR THE INSTALLATION OF "WATER TRANSMISSION MAIN REINFORCEMENT" BY CAHN ENGINEERS INC DATED AUGUST 1976 AND FROM NOTES ON NEWTON, N.J WATER WORKS CONSTRUCTION AND LITIGATION, BY L.L. TRIBUS, JUNE 1909

3 LOCATION OF CONCRETE FACING OVER OLD DAM, SHOWN IN SECTION A-A IS ESTIMATED AND MAY VARY

N 804,800

E 2,016,400

980

960

940

SURFACE

DAM KEYED
OCK

920

900

MORRIS LAKE DAM

NEWTON NEW JERSEY

DAM PLAN, PROFILE AND SECTION

LANGAN ENGINEERING ASSOCIATES, INC.

990 CLIFTON AVENUE CLIFTON, N.J. [illegible]

DRN. BY B.A.	SCALE AS SHOWN	JOB No. [illegible]
CK'D BY B.A.	DATE [illegible]	FIG. No. 2

APPENDIX 1

HYDROLOGIC AND HYDRAULIC DATA

CHECK LIST VISUAL INSPECTION

CHECK LIST ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 1.07 sq. mi, wooded or forest land, 5.4% avg. slope

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 939.6 ft MSL (approx 2470 ac ft)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 942.8 (approx 2985 ac ft) Assumes top of dam

ELEVATION MAXIMUM DESIGN POOL: 942.8 (Assumes top of dam)

ELEVATION TOP DAM: 942.8

CREST: Spillway

a. Elevation 939.6
b. Type Broad crested trapazoidal weir
c. Width 5 ft
d. Length 14 ft
e. Location Spillover west abutment
f. Number and Type of Gates None

OUTLET WORKS:

a. Type 16 and 12 inch dia. water supply mains
b. Location Below gatehouse
c. Entrance inverts Approx El 920 for both
d. Exit inverts Approx El 920 for both
e. Emergency draindown facilities None

HYDROMETEOROLOGICAL GAGES: None observed
a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: 283 cfs @ top of dam

Check List
Visual Inspection
Phase 1

Name Dam MORRIS LAKE DAM **County** SUSSEX **State** N.J. **Coordinators** N. J. DEP

Date(s) Inspection 9/12/80, 12/1/80 **Weather** Clear, Clear **Temperature** Low 70's, Low 40's

Pool Elevation at Time of Inspection Approx 936.4 **M.S.L.** **Tailwater at Time of Inspection** Approx 930.8 **M.S.L.**

Inspection Personnel:

R. W. Greene, LEA (9/12/80)	D. Leary, LEA (12/1/80)
V. Urban, LEA (9/12/80)	P. Yu, LEA (12/1/80)
Mr. Harold Beemer, New Water Department (9/12/80)	

R. W. Greene **Recorder**

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE	LIMITED SEEPAGE ON DOWNSTREAM FACE BELOW GATEHOUSE APPROX 10 FT DOWN FROM TOP OF DAM.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	EAST SIDE-DAM ABUTS TO ROCK OUTCROP - NO SIGNS OF LEAKAGE U/S CONCRETE DETERIORATING AT EAST ABUTMENT. WEST SIDE - DAM ABUTS TO ROCK LEDGE NO SIGN OF LEAKAGE.	REPAIR DETERIORATED CONCRETE.
DRAINS	NONE OBSERVED	
WATER PASSAGES	NO APPARENT DEFECTS OBSERVED.	
FOUNDATION	REPORTED TO BE BEDROCK.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	NUMEROUS CRACKS AND SPALLING OF CONCRETE (GUNITE) FACING ALONG UPSTREAM & DOWNSTREAM FACE. GRASS GROWING OUT OF MANY CRACKS ON THE DOWNSTREAM FACE.	INVESTIGATE EXTENT OF DETERIORATION. REPAIR IF NECESSARY.
STRUCTURAL CRACKING	NONE OBSERVED.	
VERTICAL AND HORIZONTAL ALIGNMENT	VERTICAL - ARCHED UPSTREAM HORIZONTAL - LEVEL	
MONOLITH JOINTS	SPILLWAY APPEARED TIGHT, NO SIGNS OF LEAKAGE.	
CONSTRUCTION JOINTS	APPEARED TIGHT, NO SIGNS OF LEAKAGE.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	12 INCHE CI AND 16 INCH RCP WATER SUPPLY TO TOWN OF NEWTON EMERGENCY PUMP IN GATE HOUSE WELL	PIPELINES NOT VISIBLE
INTAKE STRUCTURE	CANNOT BE INSPECTED	
OUTLET STRUCTURE	NONE. WATER SUPPLY LINES TO TOWN OF NEWTON.	
OUTLET CHANNEL	ROCK OUTCROP FROM SPILLWAY TO LARGE POND (GLEN LAKE) ADJACENT TO DOWNSTREAM FACE OF DAM.	
EMERGENCY GATE	NONE.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	NO APPARENT DEFECTS OBSERVED.	
APPROACH CHANNEL	NONE - UNOBSTRUCTED	
DISCHARGE CHANNEL	NATURAL ROCK OUTCROP TO GLEN LAKE IMMEDIATELY DOWNSTREAM OF DAM. BRUSH GROWING IN CHANNEL.	REMOVE BRUSH.
BRIDGE AND PIERS	FOOT PATH STRUCTURE SPANS OVER SPILLWAY TO FORM FOOT BRIDGE. NO APPARENT DEFECTS OBSERVED.	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	TOWN OF NEWTON MONUMENTS. NO REFERENCE MARKS FOUND ON MONUMENTS.	
OBSERVATION WELLS	NONE OBSERVED	
WEIRS	FLOW METERS IN GATE HOUSE FOR 16 INCH AND 12 INCH WATER SUPPLY LINES.	
PIEZOMETERS	NONE OBSERVED	
OTHER	POOL LEVELS TAKEN DAILY BY NEWTON WATER DEPT.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	LARGE PRIVATE POND (GLEN LAKE)	
SLOPES	APPROX 2:1 TO 4:1 EAST SIDE APPROX 10:1 WEST SIDE TREES AND LAWNS & ROCK OUTCROPS	
APPROXIMATE NO. OF HOMES AND POPULATION	APPROX 20 HOMES AROUND GLEN LAKE. ALL APPEAR ABOVE DAM ELEVATION. NORTHERN PORTION OF THE TOWN OF SPARTA IS LOCATED APPROX 1 1/2 MILES FROM THE DAM.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	APPROX 2H: 1 VERTICAL - ROCK OUTCROPS RIPRAP APPEARS EVEN & WELL PLACED AROUND SHORELINE VISIBLE FROM DAM.	
SEDIMENTATION	NONE OBSERVED WITH THE EXCEPTION OF SLIGHT BOTTOM GROWTH.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM NOTES ON NEWTON, N.J. WATER WORKS CONSTRUCTION AND LITIGATION. NEW ENGLAND WATER WORKS ASSOC. VOL 23, No. 2, JUNE 1909 BY LOUIS L. TRIBUS	MORRIS LAKE DAM DAM PLAN, PROFILE AND SECTION
REGIONAL VICINITY MAP SEE FIG. 1	MORRIS LAKE DAM, HIGH STREET RESERVOIR DAM TOWN OF NEWTON, NEWTON, N.J. PHASE I INSPECTION REPORT BY CAHN ENGINEERING, INC., WALLINGFORD, CONN. MARCH 1979.
CONSTRUCTION HISTORY NOTES ON NEWTON, N.J. WATER WORKS CONSTRUCTION AND LITIGATION. NEW ENGLAND WATER WORKS ASSOC., VOL 23, NO. 2, JUNE 1909 BY LOUIS L. TRIBUS	MORRIS LAKE DAM, HIGH STREET RESERVOIR DAM TOWN OF NEWTON, NEWTON, N.J. PHASE I INSPECTION REPORT BY CAHN ENGINEERING, INC., WALLINGFORD, CONN., MARCH 1979.
TYPICAL SECTIONS OF DAM NOTES ON NEWTON, N.J. WATER WORKS CONSTRUCTION AND LITIGATION. NEW ENGLAND WATER WORKS ASSOC., VOL 23, NO. 2, JUNE 1909 BY LOUIS L. TRIBUS	MORRIS LAKE DAM DAM PLAN, PROFILE AND SECTION
HYDROLOGIC/HYDRAULIC DATA	
OUTLETS - PLAN MORRIS LAKE DAM DAM PLAN, PROFILE AND SECTION	
- DETAILS	
-CONSTRAINTS	
-DISCHARGE RATINGS	
RAINFALL/RESERVOIR RECORDS NONE AVAILABLE	

ITEM	REMARKS
DESIGN REPORTS	NONE AVAILABLE
GEOLOGY REPORTS	NONE ABAILABLE
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	NONE AVAILABLE
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	NONE AVAILABLE
POST-CONSTRUCTION SURVEYS OF DAM	MORRIS LAKE DAM DAM PLAN, PROFILE AND SECTION
BORROW SOURCES.	REPORTED TO BE LOCAL ROCK AT DAMSITE.

ITEM	REMARKS
MONITORING SYSTEMS	FLOW METER ON 12 INCH AND 16 INCH WATER SUPPLY PIPELINES.
MODIFICATIONS	RESURFACING, RAISING AND CONSTRUCTION OF GATE HOUSE IN 1927. NEW 20 INCH WATER INTAKE INSTALLED IN 1929. 16 INCH WATER SUPPLY MAIN INSTALLED IN 1978 THROUGH 24 INCH LOW LEVEL OUTLET.
HIGH POOL RECORDS	UNAVAILABLE.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	MORRIS LAKE DAM, HIGH STREET RESERVOIR DAM TOWN OF NEWTON, NEWTON, N. J. PHASE I INSPECTION REPORT BY CAHN ENGINEERING, INC., WALLINGFORD, CONN. MARCH 1979
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	NONE REPORTED
MAINTENANCE OPERATION RECORDS	DAILY FLOW RECORDS OF 12 INCH AND 16 INCH WATER SUPPLY MAINS.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	MORRIS LAKE DAM, HIGH STREET RESERVOIR DAM TOWN OF NEWTON, NEWTON, N.J. PHASE I INSPECTION REPORT BY CAHN ENGINEERING, INC. WALLINGFORD, CONN., MARCH 1979
OPERATING EQUIPMENT PLANS & DETAILS	MORRIS LAKE DAM, HIGH STREET RESERVOIR DAM TOWN OF NEWTON, NEWTON, N.J. PHASE I INSPECTION REPORT BY CAHN ENGINEERING, INC., WALLINGFORD, CONN., MARCH 1979

APPENDIX 2

PHOTOGRAPHS

Downstream face of dam. Looking west from east side of dam. 12 September 1980

Downstream wing wall west of spillway and discharge channel. 12 September 1980

Upstream face of dam, east side, showing east abutment and gate house. 12 September 1980

Upstream face of dam, west side, showing spillway opening. 12 September 1980

West shoreline of Reservoir viewed from center of dam		12 September 1980

East shoreline of Reservoir viewed from center of dam.		12 September 1980

APPENDIX 3

HYDROLOGIC COMPUTATIONS

HYDROLOGICAL COMPUTATIONS
MORRIS LAKE DAM

A. Location: Sussex County, N.J. - Wallkill River

B. Drainage Area: 1.07 sq. mi (684 acres)

C. Lake area: 157 acres

D. Classification: size - intermediate
hazard - high

E. Spillway Design Flood: PMF

F. PMP

1. Dam located in zone 6 (near zone 1 boundary)
   PMP = 22.3 inches (for 200 sq. mi, 24 hr., "all season envelope") *

2. PMF must be adjusted for basin size under 10 sq. mi: use factor of 80%. **

% Factor for ≤10 sq mi			
Duration	Zone 1	Zone 6	Avg
0-6	111	113	112
0-12	123	123	123
0-24	133	132	132
0-48	142	142	142

* HMR #33
** Page 48 "Design of Small Dams".

LANGAN ENGINEERING ASSOCIATES, INC.

G. DETERMINE TIME OF CONCENTRATION

Majority area of watershed is woodland. There is no main stream. The watercourse is overland flow over poorly defined channel & woodland

1. Estimate T_c based on average velocity and length —

$$\text{Ave slope}(Y) = \frac{1300-950}{6500} \times 100\% \doteq 5.4\%$$

Assume half of the watercourse flow over poorly defined channel and half over forest and fallow

From Fig 3-1, SCS TR-55

	Velocity
poorly defined channel	2.5 fps
forest & fallow	0.8 fps

$$T_c = \frac{3250}{2.5 \times 60 \times 60} + \frac{3250}{0.8 \times 60 \times 60} \doteq 1.5 \text{ hrs.}$$

$$L = 0.6 T_c = \underline{0.9 \text{ hrs}}$$

2. Estimate T_c from curve number method

From Table 2-2 SCS TR-55

for soil group C (County Soil Survey - Sussex N.J)

wood or forest land $CN = 74$

$$S = \frac{1000}{CN} - 10 = \frac{1000}{74} - 10 = 3.51$$

Lag time $L = \dfrac{\ell^{0.8}(S+1)^{0.7}}{1900(Y)^{0.5}}$ Eq. 3-2 TR-55

$$= \frac{6500^{0.8}(4.51)^{0.7}}{1900(5.4)^{0.5}} = \underline{0.73 \text{ hr.}}$$

Use $\boxed{L = 0.8 \text{ hr.}}$

BY Py DATE 7/17/81 Morris Lake JOB NO. 80145

CKD RWG DATE 7/19/81 SHEET NO. 2 OF

LANGAN ENGINEERING ASSOCIATES, INC.

ELEVATION	SPILLWAY L = 14 ft, h = 2 ft, w = 5 ft			DAM L = 160 ft, w = 5 ft			
	H, ft	C	Q cfs	H, ft	C	$Q = CLH^{3/2}$ Q cfs	ΣQ cfs
939.6	0	–	0				0
940.0	0.4	2.50	9				9
941.0	1.4	2.65	61				61
941.6	2.0	2.65	105				105
942.0	1.4	0.85	226				226
942.8	2.2	0.85	283	0	–		283
943.0	2.4	0.85	296	0.2	2.34	33	329
944.0	3.4	0.85	352	1.2	2.66	560	912
945.0	4.4	0.85	401	2.2	2.66	1389	1790
946.0	5.4	0.85	444	3.2	2.67	2445	2889

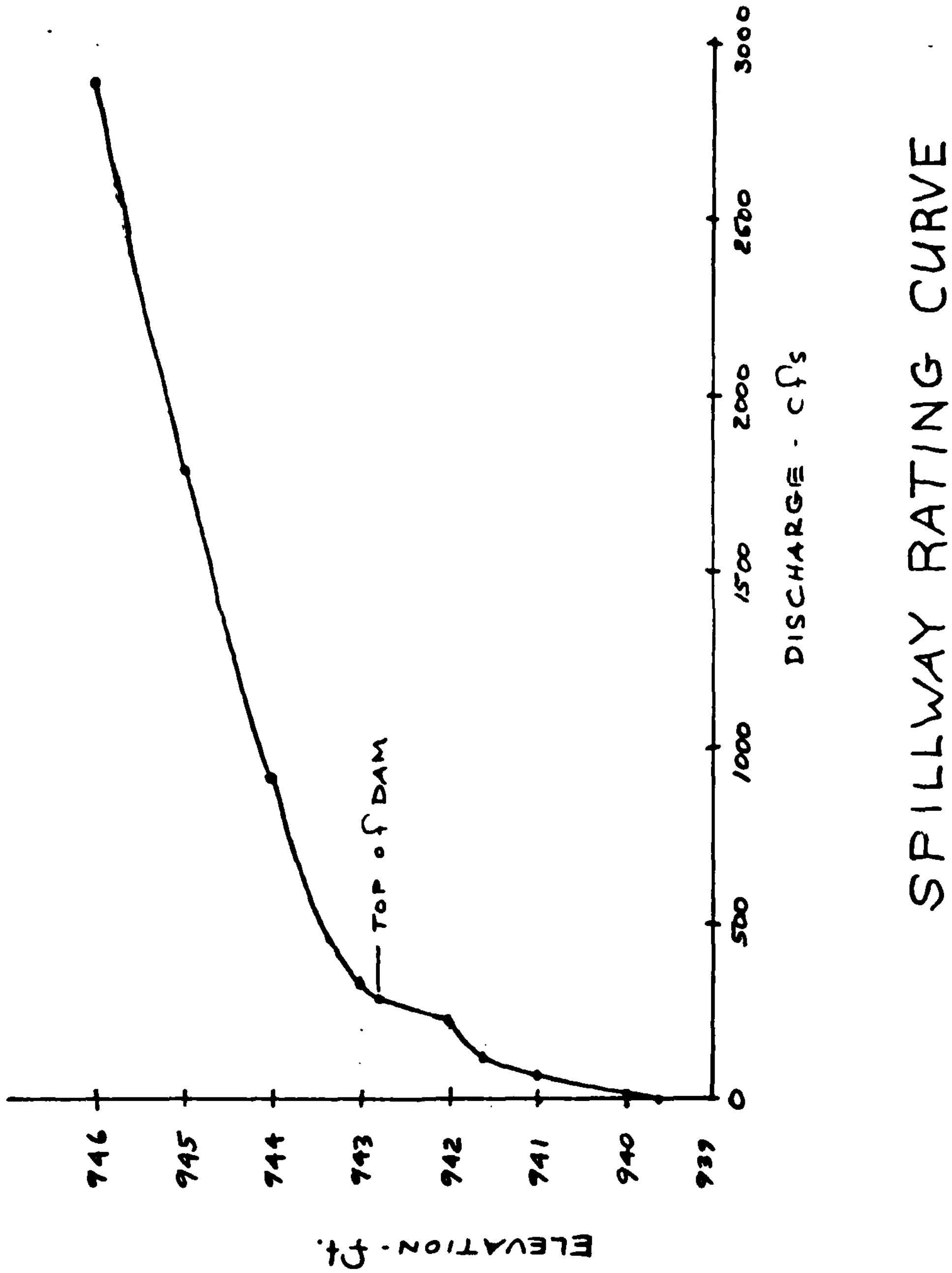
WEIR FLOW $Q = CLH^{3/2}$ C VALUES FROM HANDBOOK OF HYDRAULICS TABLE 5-3 PG 5-40

ORIFICE FLOW THRU SPILLWAY OCCURS AT EL 941.6+, $Q = CA\sqrt{2gH}$, C VALUES FROM DESIGN OF SMALL DAMS, TABLE 33, Page 472. C = 0.85 FOR SQUARE EDGED ENTRANCES.

BY RWG DATE 10/31/80 DISCHARGE SUMMARY JOB NO. 80145

CKD. [illegible] DATE 2/17/81 MORRIS LAKE DAM SHEET NO. 3 OF

LANGAN ENGINEERING ASSOCIATES, INC.



BY RWG DATE 10/31/80 SPILLWAY RATING CURVE JOB NO. 80145

CKD. [illegible] DATE 2/17/81 MORRIS LAKE DAM SHEET NO. 4 OF

Reservoir Storage Capacity

Assume a linear distribution for the area of the lake with elevation. Start at a zero storage at the crest of the spillway.

Area of Lake = 157 ac @ ≈ 939.6

Length of equivalent square = 2615.13 ft

Take average side slope: 1V : 10H

∴ for every foot of water above the crest of the spillway the length of the equivalent square increases by: 1×2×10 = 20 ft

	Elevation (ft)	H (ft)	Length of Equiv. Square (ft)	Area of Lake (acres)
SPILLWAY CREST	939.6	0	2615.13	157
	940.0	0.4	2623.13	157.96
	941.0	1.4	2643.13	160.38
	942.0	2.4	2663.13	162.82
TOP of DAM	942.8	3.2	2679.13	164.78
	943.0	3.4	2683.13	165.27
	944.0	4.4	2703.13	167.74
	945.0	5.4	2723.13	170.24
	946.0	6.4	2743.13	172.74

Storage capacity vs. elevation is calculated by HEC 1

LANGAN ENGINEERING ASSOCIATES, INC.

SUMMARY OF HYDROGRAPH AND FLOOD ROUTING

1) HYDROGRAPH & ROUTING CALCULATED USING HEC-1

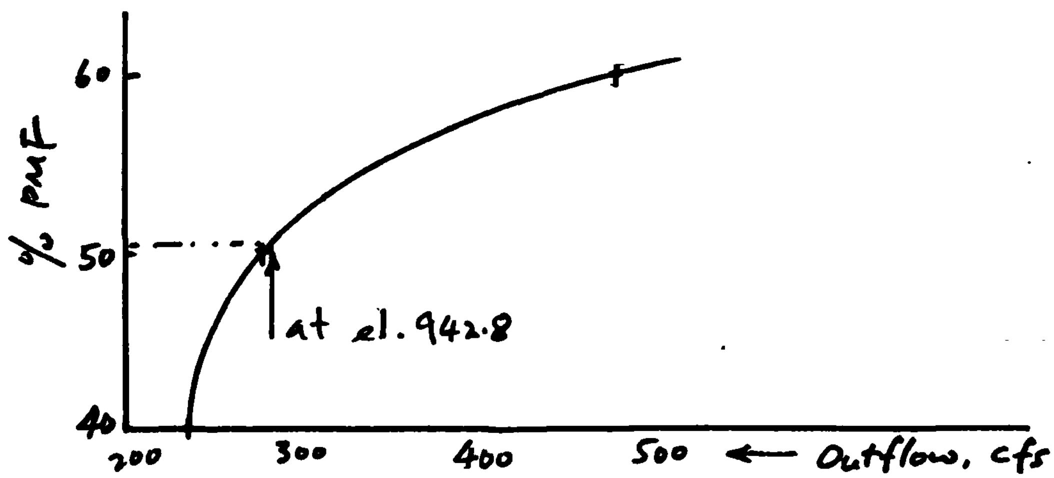
2) PMF for Morris Lake Dam is 4533 cfs (routed to 1545 cfs)

3) Routing of PMF indicates that the dam will overtop by 1.92 ft.

4) Routing of THE 1/2 PMF indicates that the dam can adequately pass the 1/2 PMF.

OVERTOPPING POTENTIAL

1) Various % of PMF have been routed using HEC-1 DB
2) Plot peak outflow vs % PMF



3) Dam overtops at elev. 942.8 with Q = 283 cfs
∴ dam can pass approx. 50% of PMF

BY RWG DATE 11/3/80 HEC-1 SUMMARY JOB NO. 80145
CKD. PJ DATE 7/11/81 SHEET NO. 6 OF

HEC-1 OUTPUT

MORRIS LAKE DAM

```
1A1             MORRIS LAKE DAM (00306)
A2              INFLOW HYDROGRAPHY AND ROUTING
A3              N.J. DAM INSPECTION
B     290       0      10       0       0       0       0       0       0       0
B1      3
K       0       1                                       1
K1 COMPUTE HYDROGRAPH
M       1       2    1.07                     .80
P       0    22.3     112     123     132     142
T                                                       1     .15
W2           0.80
X      -2               1
K       1       2                                       1
K1 ROUTING COMPUTATIONS
Y                               1
Y1      1                                                      -1
Y4  939.6     940     941   941.6     942   942.8     943     944     945     946
Y5      0      19      61     105     226     283     329     912    1790    2889
$A    157   158.0   160.4   162.8   164.8   165.3   167.7   170.2   172.7
$E  939.6   940.0   941.0   942.0   942.8   943.0   944.0   945.0   946.0
$$  939.6
$D  942.8
K      99
A
A
A
A
A
1          81/02/18. 10.19.44.     NOS 1.3 - L485.        EL4ECWC     STANDARD         MCAUTO - CYBER 175-3 1007.

                                   EEEEEEEEEEEE NN        NN DDDDDDDDDD
                                   EEEEEEEEEEEE NN        NN DDDDDDDDDDD
                                   EE           NNN       NN DD       DDD
                                   EE           NNN       NN DD        DD
                                   EE           NNNN      NN DD        DD
                                   EE           NN NN     NN DD        DD
                                   EE           NN  NN    NN DD        DD
                                   EEEEEEEEEEE  NN   NN   NN DD        DD
                                   EEEEEEEEEEE  NN    NN  NN DD        DD
                                   EE           NN     NN NN DD        DD
                                   EE           NN      NNNN DD        DD
                                   EE           NN       NNN DD        DD
                                   EE           NN       NNN DD        DD
                                   EE           NN        NN DD       DDD
                                   EEEEEEEEEEEE NN        NN DDDDDDDDDDD
                                   EEEEEEEEEEEE NN        NN DDDDDDDDDD

                              EEEEEEEEEEEE   CCCCCCCC    HH         HH   OOOOOOOO
                              EEEEEEEEEEEE  CCCCCCCCCC   HH         HH  OOOOOOOOOO
                              EE           CCC        CC HH         HH OOO        OOO
                              EE           CC            HH         HH OO          OO
```

```
EE           CC          HH          HH 00          00
EE           CC          HH          HH 00          00
EEEEEEEEEEE  CC          HHHHHHHHHHHHHH 00          00
EEEEEEEEEEE  CC          HHHHHHHHHHHHHH 00          00
EE           CC          HH          HH 00          00
EE           CC          HH          HH 00          00
EE           CC          HH          HH 00          00
EE           CC          HH          HH 00          00
EE           CCC      CC HH          HH 000        000
EEEEEEEEEEEE  CCCCCCCCCC HH          HH  0000000000
EEEEEEEEEEEE   CCCCCCCC  HH          HH   00000000
```

```
1***********************************
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION      JULY 1978
   LAST MODIFICATION  26 FEB 79
 ***********************************
      1               A1              MORRIS LAKE DAM (00306)
      2               A2              INFLOW HYDROGRAPHY AND ROUTING
      3               A3              N.J. DAM INSPECTION
      4               B     290       0      10       0       0       0       0       0       0       0
      5               B1      3
      6               K       0       1                                       1
      7               K1 COMPUTE HYDROGRAPH
      8               M       1       2    1.07                     .80
      9               P       0    22.3     112     123     132     142
     10               T                                                       1     .15
     11               W2           0.80
     12               X      -2               1
     13               K       1       2                                       1
     14               K1 ROUTING COMPUTATIONS
     15               Y                               1
     16               Y1      1                                                      -1
     17               Y4 939.6     940     941   941.6     942   942.8     943     944     945     946
     18               Y5      0      19      61     105     226     283     329     912    1790    2889
     19               $A    157   158.0   160.4   162.8   164.8   165.3   167.7   170.2   172.7
     20               $E 939.6   940.0   941.0   942.0   942.8   943.0   944.0   945.0   946.0
     21               $$ 939.6
     22               $D 942.8
     23               K      99
1                           PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                                    RUNOFF HYDROGRAPH AT           1
                                    ROUTE HYDROGRAPH TO            2
                                    END OF NETWORK

1***********************************
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
```

```
  LAST MODIFICATION  26 FEB 79
**********************************

RUN  DATE* 81/02/18.
     TIME* 10.22.02.

                              MORRIS LAKE DAM (00306)
                              INFLOW HYDROGRAPHY AND ROUTING
                              N.J. DAM INSPECTION

                                        JOB SPECIFICATION
           NQ      NHR     NMIN     IDAY      IHR      IMIN    METRC     IPLT     IPRT    NSTAN
          290        0       10        0        0         0        0        0        0        0
                                    JOPER      NWT    LROPT    TRACE
                                        3        0        0        0

    **********         **********         **********         **********         **********

                                    SUB-AREA RUNOFF COMPUTATION

            COMPUTE HYDROGRAPH

                             ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME  ISTAGE    IAUTO
                                 1        0        0        0        0        0        1        0        0

                                          HYDROGRAPH DATA
            IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
                1        2     1.07     0.00     1.07      .80    0.000        0        0        0

                                            PRECIP DATA
                     SPFE      PMS       R6      R12      R24      R48      R72      R96
                     0.00    22.30   112.00   123.00   132.00   142.00     0.00     0.00

                                             LOSS DATA
        LROPT    STRKR    DLTKR    RTIOL    ERAIN    STRKS    RTIOK    STRTL    CNSTL    ALSMX    RTIMP
            0     0.00     0.00     1.00     0.00     0.00     1.00     1.00      .15     0.00     0.00

                                       UNIT HYDROGRAPH DATA
                                   TC=  0.00      LAG=    .80

                                          RECESSION DATA
                             STRTQ=    -2.00    QRCSN=     0.00    RTIOR= 1.00

          UNIT HYDROGRAPH 26 END OF PERIOD ORDINATES, TC=     0.00 HOURS, LAG=    .80  VOL= 1.00
             54.      166.      349.      515.      582.      568.      494.      391.      270.      198.
            148.      110.       80.       59.       43.       31.       23.       17.       13.        9.
              7.        5.        4.        3.        2.        1.

      0                                        END-OF-PERIOD FLOW
    MO.DA   HR.MN   PERIOD    RAIN    EXCS    LOSS     COMP Q        MO.DA   HR.MN   PERIOD    RAIN    EXCS    LOSS     COMP Q

     1.01     .10        1     .00    0.00     .00         2.         1.02     .20      146     .02    0.00     .02         2.
     1.01     .20        2     .00    0.00     .00         2.         1.02     .30      147     .02    0.00     .02         2.
     1.01     .30        3     .00    0.00     .00         2.         1.02     .40      148     .02    0.00     .02         2.
     1.01     .40        4     .00    0.00     .00         2.         1.02     .50      149     .02    0.00     .02         2.
     1.01     .50        5     .00    0.00     .00         2.         1.02    1.00      150     .02    0.00     .02         2.
     1.01    1.00        6     .00    0.00     .00         2.         1.02    1.10      151     .02    0.00     .02         2.
     1.01    1.10        7     .00    0.00     .00         2.         1.02    1.20      152     .02    0.00     .02         2.
     1.01    1.20        8     .00    0.00     .00         2.         1.02    1.30      153     .02    0.00     .02         2.
     1.01    1.30        9     .00    0.00     .00         2.         1.02    1.40      154     .02    0.00     .02         2.
     1.01    1.40       10     .00    0.00     .00         2.         1.02    1.50      155     .02    0.00     .02         2.
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.01	2.00	12	.00	0.00	.00	2.	1.02	2.10	157	.02	0.00	.02	2.
1.01	2.10	13	.00	0.00	.00	2.	1.02	2.20	158	.02	0.00	.02	2.
1.01	2.20	14	.00	0.00	.00	2.	1.02	2.30	159	.02	0.00	.02	2.
1.01	2.30	15	.00	0.00	.00	2.	1.02	2.40	160	.02	0.00	.02	2.
1.01	2.40	16	.00	0.00	.00	2.	1.02	2.50	161	.02	0.00	.02	2.
1.01	2.50	17	.00	0.00	.00	2.	1.02	3.00	162	.02	0.00	.02	2.
1.01	3.00	18	.00	0.00	.00	2.	1.02	3.10	163	.02	0.00	.02	2.
1.01	3.10	19	.00	0.00	.00	2.	1.02	3.20	164	.02	0.00	.02	2.
1.01	3.20	20	.00	0.00	.00	2.	1.02	3.30	165	.02	0.00	.02	2.
1.01	3.30	21	.00	0.00	.00	2.	1.02	3.40	166	.02	0.00	.02	2.
1.01	3.40	22	.00	0.00	.00	2.	1.02	3.50	167	.02	0.00	.02	2.
1.01	3.50	23	.00	0.00	.00	2.	1.02	4.00	168	.02	0.00	.02	2.
1.01	4.00	24	.00	0.00	.00	2.	1.02	4.10	169	.02	0.00	.02	2.
1.01	4.10	25	.00	0.00	.00	2.	1.02	4.20	170	.02	0.00	.02	2.
1.01	4.20	26	.00	0.00	.00	2.	1.02	4.30	171	.02	0.00	.02	2.
1.01	4.30	27	.00	0.00	.00	2.	1.02	4.40	172	.02	0.00	.02	2.
1.01	4.40	28	.00	0.00	.00	2.	1.02	4.50	173	.02	0.00	.02	2.
1.01	4.50	29	.00	0.00	.00	2.	1.02	5.00	174	.02	0.00	.02	2.
1.01	5.00	30	.00	0.00	.00	2.	1.02	5.10	175	.02	0.00	.02	2.
1.01	5.10	31	.00	0.00	.00	2.	1.02	5.20	176	.02	0.00	.02	2.
1.01	5.20	32	.00	0.00	.00	2.	1.02	5.30	177	.02	0.00	.02	2.
1.01	5.30	33	.00	0.00	.00	2.	1.02	5.40	178	.02	0.00	.02	2.
1.01	5.40	34	.00	0.00	.00	2.	1.02	5.50	179	.02	0.00	.02	2.
1.01	5.50	35	.00	0.00	.00	2.	1.02	6.00	180	.02	0.00	.02	2.
1.01	6.00	36	.00	0.00	.00	2.	1.02	6.10	181	.05	.03	.03	4.
1.01	6.10	37	.00	0.00	.00	2.	1.02	6.20	182	.05	.03	.03	9.
1.01	6.20	38	.00	0.00	.00	2.	1.02	6.30	183	.05	.03	.03	19.
1.01	6.30	39	.00	0.00	.00	2.	1.02	6.40	184	.05	.03	.03	34.
1.01	6.40	40	.00	0.00	.00	2.	1.02	6.50	185	.05	.03	.03	51.
1.01	6.50	41	.00	0.00	.00	2.	1.02	7.00	186	.05	.03	.03	68.
1.01	7.00	42	.00	0.00	.00	2.	1.02	7.10	187	.05	.03	.03	83.
1.01	7.10	43	.00	0.00	.00	2.	1.02	7.20	188	.05	.03	.03	94.
1.01	7.20	44	.00	0.00	.00	2.	1.02	7.30	189	.05	.03	.03	102.
1.01	7.30	45	.00	0.00	.00	2.	1.02	7.40	190	.05	.03	.03	108.
1.01	7.40	46	.00	0.00	.00	2.	1.02	7.50	191	.05	.03	.03	112.
1.01	7.50	47	.00	0.00	.00	2.	1.02	8.00	192	.05	.03	.03	116.
1.01	8.00	48	.00	0.00	.00	2.	1.02	8.10	193	.05	.03	.03	118.
1.01	8.10	49	.00	0.00	.00	2.	1.02	8.20	194	.05	.03	.03	120.
1.01	8.20	50	.00	0.00	.00	2.	1.02	8.30	195	.05	.03	.03	121.
1.01	8.30	51	.00	0.00	.00	2.	1.02	8.40	196	.05	.03	.03	122.
1.01	8.40	52	.00	0.00	.00	2.	1.02	8.50	197	.05	.03	.03	123.
1.01	8.50	53	.00	0.00	.00	2.	1.02	9.00	198	.05	.03	.03	123.
1.01	9.00	54	.00	0.00	.00	2.	1.02	9.10	199	.05	.03	.03	123.
1.01	9.10	55	.00	0.00	.00	2.	1.02	9.20	200	.05	.03	.03	124.
1.01	9.20	56	.00	0.00	.00	2.	1.02	9.30	201	.05	.03	.03	124.
1.01	9.30	57	.00	0.00	.00	2.	1.02	9.40	202	.05	.03	.03	124.
1.01	9.40	58	.00	0.00	.00	2.	1.02	9.50	203	.05	.03	.03	124.
1.01	9.50	59	.00	0.00	.00	2.	1.02	10.00	204	.05	.03	.03	124.
1.01	10.00	60	.00	0.00	.00	2.	1.02	10.10	205	.05	.03	.03	124.
1.01	10.10	61	.00	0.00	.00	2.	1.02	10.20	206	.05	.03	.03	124.
1.01	10.20	62	.00	0.00	.00	2.	1.02	10.30	207	.05	.03	.03	124.
1.01	10.30	63	.00	0.00	.00	2.	1.02	10.40	208	.05	.03	.03	124.
1.01	10.40	64	.00	0.00	.00	2.	1.02	10.50	209	.05	.03	.03	124.
1.01	10.50	65	.00	0.00	.00	2.	1.02	11.00	210	.05	.03	.03	124.
1.01	11.00	66	.00	0.00	.00	2.	1.02	11.10	211	.05	.03	.03	124.
1.01	11.10	67	.00	0.00	.00	2.	1.02	11.20	212	.05	.03	.03	124.
1.01	11.20	68	.00	0.00	.00	2.	1.02	11.30	213	.05	.03	.03	124.
1.01	11.30	69	.00	0.00	.00	2.	1.02	11.40	214	.05	.03	.03	124.
1.01	11.40	70	.00	0.00	.00	2.	1.02	11.50	215	.05	.03	.03	124.
1.01	11.50	71	.00	0.00	.00	2.	1.02	12.00	216	.05	.03	.03	124.
1.01	12.00	72	.00	0.00	.00	2.	1.02	12.10	217	.33	.31	.03	139.
1.01	12.10	73	.03	0.00	.03	2.	1.02	12.20	218	.33	.31	.03	185.
1.01	12.20	74	.03	0.00	.03	2.	1.02	12.30	219	.33	.31	.03	283.
1.01	12.30	75	.03	0.00	.03	2.	1.02	12.40	220	.33	.31	.03	426.
1.01	12.40	76	.03	0.00	.03	2.	1.02	12.50	221	.33	.31	.03	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.01	13.00	78	.03	0.00	.03	2.	1.02	13.10	223	.40	.37	.03	887.
1.01	13.10	79	.03	0.00	.03	2.	1.02	13.20	224	.40	.37	.03	1007.
1.01	13.20	80	.03	0.00	.03	2.	1.02	13.30	225	.40	.37	.03	1106.
1.01	13.30	81	.03	0.00	.03	2.	1.02	13.40	226	.40	.37	.03	1195.
1.01	13.40	82	.03	0.00	.03	2.	1.02	13.50	227	.40	.37	.03	1275.
1.01	13.50	83	.03	0.00	.03	2.	1.02	14.00	228	.40	.37	.03	1344.
1.01	14.00	84	.03	0.00	.03	2.	1.02	14.10	229	.50	.47	.03	1404.
1.01	14.10	85	.04	0.00	.04	2.	1.02	14.20	230	.50	.47	.03	1463.
1.01	14.20	86	.04	0.00	.04	2.	1.02	14.30	231	.50	.47	.03	1528.
1.01	14.30	87	.04	0.00	.04	2.	1.02	14.40	232	.50	.47	.03	1601.
1.01	14.40	88	.04	0.00	.04	2.	1.02	14.50	233	.50	.47	.03	1676.
1.01	14.50	89	.04	0.00	.04	2.	1.02	15.00	234	.50	.47	.03	1745.
1.01	15.00	90	.04	0.00	.04	2.	1.02	15.10	235	.46	.43	.03	1801.
1.01	15.10	91	.03	0.00	.03	2.	1.02	15.20	236	.76	.73	.03	1855.
1.01	15.20	92	.06	0.00	.06	2.	1.02	15.30	237	1.37	1.34	.03	1955.
1.01	15.30	93	.10	0.00	.10	2.	1.02	15.40	238	3.42	3.39	.03	2272.
1.01	15.40	94	.26	.19	.07	12.	1.02	15.50	239	.99	.96	.03	2841.
1.01	15.50	95	.07	.05	.03	36.	1.02	16.00	240	.61	.58	.03	3610.
1.01	16.00	96	.05	.02	.03	78.	1.02	16.10	241	.47	.44	.03	4263.
1.01	16.10	97	.04	.01	.03	122.	1.02	16.20	242	.47	.44	.03	4533.
1.01	16.20	98	.04	.01	.03	149.	1.02	16.30	243	.47	.44	.03	4450.
1.01	16.30	99	.04	.01	.03	157.	1.02	16.40	244	.47	.44	.03	4103.
1.01	16.40	100	.04	.01	.03	148.	1.02	16.50	245	.47	.44	.03	3628.
1.01	16.50	101	.04	.01	.03	131.	1.02	17.00	246	.47	.44	.03	3126.
1.01	17.00	102	.04	.01	.03	107.	1.02	17.10	247	.37	.34	.03	2772.
1.01	17.10	103	.03	.00	.03	89.	1.02	17.20	248	.37	.34	.03	2509.
1.01	17.20	104	.03	.00	.03	76.	1.02	17.30	249	.37	.34	.03	2293.
1.01	17.30	105	.03	.00	.03	65.	1.02	17.40	250	.37	.34	.03	2102.
1.01	17.40	106	.03	.00	.03	55.	1.02	17.50	251	.37	.34	.03	1943.
1.01	17.50	107	.03	.00	.03	46.	1.02	18.00	252	.37	.34	.03	1811.
1.01	18.00	108	.03	.00	.03	38.	1.02	18.10	253	.03	.00	.03	1688.
1.01	18.10	109	.00	0.00	.00	31.	1.02	18.20	254	.03	.00	.03	1554.
1.01	18.20	110	.00	0.00	.00	26.	1.02	18.30	255	.03	.00	.03	1379.
1.01	18.30	111	.00	0.00	.00	22.	1.02	18.40	256	.03	.00	.03	1163.
1.01	18.40	112	.00	0.00	.00	18.	1.02	18.50	257	.03	.00	.03	935.
1.01	18.50	113	.00	0.00	.00	14.	1.02	19.00	258	.03	.00	.03	720.
1.01	19.00	114	.00	0.00	.00	11.	1.02	19.10	259	.03	.00	.03	536.
1.01	19.10	115	.00	0.00	.00	9.	1.02	19.20	260	.03	.00	.03	391.
1.01	19.20	116	.00	0.00	.00	7.	1.02	19.30	261	.03	.00	.03	289.
1.01	19.30	117	.00	0.00	.00	6.	1.02	19.40	262	.03	.00	.03	213.
1.01	19.40	118	.00	0.00	.00	5.	1.02	19.50	263	.03	.00	.03	156.
1.01	19.50	119	.00	0.00	.00	4.	1.02	20.00	264	.03	.00	.03	115.
1.01	20.00	120	.00	0.00	.00	3.	1.02	20.10	265	.03	.00	.03	86.
1.01	20.10	121	.00	0.00	.00	3.	1.02	20.20	266	.03	.00	.03	65.
1.01	20.20	122	.00	0.00	.00	3.	1.02	20.30	267	.03	.00	.03	50.
1.01	20.30	123	.00	0.00	.00	3.	1.02	20.40	268	.03	.00	.03	39.
1.01	20.40	124	.00	0.00	.00	2.	1.02	20.50	269	.03	.00	.03	30.
1.01	20.50	125	.00	0.00	.00	2.	1.02	21.00	270	.03	.00	.03	24.
1.01	21.00	126	.00	0.00	.00	2.	1.02	21.10	271	.03	.00	.03	20.
1.01	21.10	127	.00	0.00	.00	2.	1.02	21.20	272	.03	.00	.03	17.
1.01	21.20	128	.00	0.00	.00	2.	1.02	21.30	273	.03	.00	.03	14.
1.01	21.30	129	.00	0.00	.00	2.	1.02	21.40	274	.03	.00	.03	12.
1.01	21.40	130	.00	0.00	.00	2.	1.02	21.50	275	.03	.00	.03	11.
1.01	21.50	131	.00	0.00	.00	2.	1.02	22.00	276	.03	.00	.03	10.
1.01	22.00	132	.00	0.00	.00	2.	1.02	22.10	277	.03	.00	.03	10.
1.01	22.10	133	.00	0.00	.00	2.	1.02	22.20	278	.03	.00	.03	9.
1.01	22.20	134	.00	0.00	.00	2.	1.02	22.30	279	.03	.00	.03	9.
1.01	22.30	135	.00	0.00	.00	2.	1.02	22.40	280	.03	.00	.03	9.
1.01	22.40	136	.00	0.00	.00	2.	1.02	22.50	281	.03	.00	.03	9.
1.01	22.50	137	.00	0.00	.00	2.	1.02	23.00	282	.03	.00	.03	9.
1.01	23.00	138	.00	0.00	.00	2.	1.02	23.10	283	.03	.00	.03	9.
1.01	23.10	139	.00	0.00	.00	2.	1.02	23.20	284	.03	.00	.03	9.
1.01	23.20	140	.00	0.00	.00	2.	1.02	23.30	285	.03	.00	.03	9.
1.01	23.30	141	.00	0.00	.00	2.	1.02	23.40	286	.03	.00	.03	9.
1.01	23.40	142	.00	0.00	.00	2.	1.02	23.50	287	.03	.00	.03	9.

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1.02   0.00    144   .00  0.00   .00      2.      1.03   .10    289  0.00  0.00  0.00      9.
1.02    .10    145   .02  0.00   .02      2.      1.03   .20    290  0.00  0.00  0.00      9.

                                                               SUM  25.33  20.55   4.79   85641.
                                                                   ( 643.)( 522.)( 122.)( 2425.08)

                               PEAK    6-HOUR   24-HOUR   72-HOUR    TOTAL VOLUME
                    CFS        4533.    2099.     583.      295.         85670.
                    CMS         128.      59.      17.        8.          2426.
                 INCHES                 18.25    20.27     20.69          20.69
                     MM                463.43   514.94    525.49         525.49
                  AC-FT                 1041.    1156.     1180.          1180.
             THOUS CU M                 1284.    1426.     1456.          1456.


         **********        **********        **********        **********        **********

                                            HYDROGRAPH ROUTING

              ROUTING COMPUTATIONS

                          ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                              2       1       0       0       0       0       1       0       0
                                                ROUTING DATA
                  QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
                    0.0   0.000    0.00       1       0       0       0               0

                          NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                              1       0       0   0.000   0.000   0.000      0.      -1

  STAGE     939.60     940.00     941.00     941.60     942.00     942.80     943.00     944.00     945.00     946.00

   FLOW       0.00      19.00      61.00     105.00     226.00     283.00     329.00     912.00    1790.00    2889.00

SURFACE AREA=     157.      158.      160.      163.      165.      165.      168.      170.      173.

    CAPACITY=       0.       63.      222.      384.      515.      548.      714.      883.     1055.

   ELEVATION=     940.      940.      941.      942.      943.      943.      944.      945.      946.

                       CREL   SPWID    COQW    EXPW   ELEVL    COQL   CAREA    EXPL
                      939.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0

                                                   DAM DATA
                                          TOPEL    COQD    EXPD  DAMWID
                                          942.8     0.0     0.0      0.

                                         END-OF-PERIOD HYDROGRAPH ORDINATES
                      MO.DA   HR.MN  PERIOD  HOURS     INFLOW   OUTFLOW   STORAGE     STAGE

                       1.01     .10      1     .17        2.        0.        0.     939.6
                       1.01     .20      2     .33        2.        0.        0.     939.6
                       1.01     .30      3     .50        2.        0.        0.     939.6
                       1.01     .40      4     .67        2.        0.        0.     939.6
                       1.01     .50      5     .83        2.        0.        0.     939.6
                       1.01    1.00      6    1.00        2.        0.        0.     939.6
                       1.01    1.10      7    1.17        2.        0.        0.     939.6
                       1.01    1.20      8    1.33        2.        0.        0.     939.6
                       1.01    1.30      9    1.50        2.        0.        0.     939.6
                       1.01    1.40     10    1.67        2.        0.        0.     939.6
                       1.01    1.50     11    1.83        2.        0.        0.     939.6
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1.01	2.20	14	2.33	2.	0.	0.	939.6
1.01	2.30	15	2.50	2.	0.	0.	939.6
1.01	2.40	16	2.67	2.	0.	0.	939.6
1.01	2.50	17	2.83	2.	0.	0.	939.6
1.01	3.00	18	3.00	2.	0.	1.	939.6
1.01	3.10	19	3.17	2.	0.	1.	939.6
1.01	3.20	20	3.33	2.	0.	1.	939.6
1.01	3.30	21	3.50	2.	0.	1.	939.6
1.01	3.40	22	3.67	2.	0.	1.	939.6
1.01	3.50	23	3.83	2.	0.	1.	939.6
1.01	4.00	24	4.00	2.	0.	1.	939.6
1.01	4.10	25	4.17	2.	0.	1.	939.6
1.01	4.20	26	4.33	2.	0.	1.	939.6
1.01	4.30	27	4.50	2.	0.	1.	939.6
1.01	4.40	28	4.67	2.	0.	1.	939.6
1.01	4.50	29	4.83	2.	0.	1.	939.6
1.01	5.00	30	5.00	2.	0.	1.	939.6
1.01	5.10	31	5.17	2.	0.	1.	939.6
1.01	5.20	32	5.33	2.	0.	1.	939.6
1.01	5.30	33	5.50	2.	0.	1.	939.6
1.01	5.40	34	5.67	2.	0.	1.	939.6
1.01	5.50	35	5.83	2.	0.	1.	939.6
1.01	6.00	36	6.00	2.	0.	1.	939.6
1.01	6.10	37	6.17	2.	0.	1.	939.6
1.01	6.20	38	6.33	2.	0.	1.	939.6
1.01	6.30	39	6.50	2.	0.	1.	939.6
1.01	6.40	40	6.67	2.	0.	1.	939.6
1.01	6.50	41	6.83	2.	0.	1.	939.6
1.01	7.00	42	7.00	2.	0.	1.	939.6
1.01	7.10	43	7.17	2.	0.	1.	939.6
1.01	7.20	44	7.33	2.	0.	1.	939.6
1.01	7.30	45	7.50	2.	0.	1.	939.6
1.01	7.40	46	7.67	2.	0.	1.	939.6
1.01	7.50	47	7.83	2.	0.	1.	939.6
1.01	8.00	48	8.00	2.	0.	1.	939.6
1.01	8.10	49	8.17	2.	0.	1.	939.6
1.01	8.20	50	8.33	2.	0.	1.	939.6
1.01	8.30	51	8.50	2.	0.	1.	939.6
1.01	8.40	52	8.67	2.	0.	1.	939.6
1.01	8.50	53	8.83	2.	0.	1.	939.6
1.01	9.00	54	9.00	2.	0.	1.	939.6
1.01	9.10	55	9.17	2.	0.	1.	939.6
1.01	9.20	56	9.33	2.	0.	1.	939.6
1.01	9.30	57	9.50	2.	0.	1.	939.6
1.01	9.40	58	9.67	2.	0.	2.	939.6
1.01	9.50	59	9.83	2.	0.	2.	939.6
1.01	10.00	60	10.00	2.	0.	2.	939.6
1.01	10.10	61	10.17	2.	0.	2.	939.6
1.01	10.20	62	10.33	2.	0.	2.	939.6
1.01	10.30	63	10.50	2.	0.	2.	939.6
1.01	10.40	64	10.67	2.	1.	2.	939.6
1.01	10.50	65	10.83	2.	1.	2.	939.6
1.01	11.00	66	11.00	2.	1.	2.	939.6
1.01	11.10	67	11.17	2.	1.	2.	939.6
1.01	11.20	68	11.33	2.	1.	2.	939.6
1.01	11.30	69	11.50	2.	1.	2.	939.6
1.01	11.40	70	11.67	2.	1.	2.	939.6
1.01	11.50	71	11.83	2.	1.	2.	939.6
1.01	12.00	72	12.00	2.	1.	2.	939.6
1.01	12.10	73	12.17	2.	1.	2.	939.6
1.01	12.20	74	12.33	2.	1.	2.	939.6
1.01	12.30	75	12.50	2.	1.	2.	939.6
1.01	12.40	76	12.67	2.	1.	2.	939.6
1.01	12.50	77	12.83	2.	1.	2.	939.6
1.01	13.00	78	13.00	2.	1.	2.	939.6

1.01	13.20	80	13.33	2.	1.	2.	939.6
1.01	13.30	81	13.50	2.	1.	2.	939.6
1.01	13.40	82	13.67	2.	1.	2.	939.6
1.01	13.50	83	13.83	2.	1.	2.	939.6
1.01	14.00	84	14.00	2.	1.	2.	939.6
1.01	14.10	85	14.17	2.	1.	2.	939.6
1.01	14.20	86	14.33	2.	1.	2.	939.6
1.01	14.30	87	14.50	2.	1.	2.	939.6
1.01	14.40	88	14.67	2.	1.	2.	939.6
1.01	14.50	89	14.83	2.	1.	2.	939.6
1.01	15.00	90	15.00	2.	1.	2.	939.6
1.01	15.10	91	15.17	2.	1.	2.	939.6
1.01	15.20	92	15.33	2.	1.	2.	939.6
1.01	15.30	93	15.50	2.	1.	2.	939.6
1.01	15.40	94	15.67	12.	1.	2.	939.6
1.01	15.50	95	15.83	36.	1.	3.	939.6
1.01	16.00	96	16.00	78.	1.	3.	939.6
1.01	16.10	97	16.17	122.	1.	5.	939.6
1.01	16.20	98	16.33	149.	2.	7.	939.6
1.01	16.30	99	16.50	157.	3.	9.	939.7
1.01	16.40	100	16.67	148.	3.	11.	939.7
1.01	16.50	101	16.83	131.	4.	13.	939.7
1.01	17.00	102	17.00	107.	4.	14.	939.7
1.01	17.10	103	17.17	89.	5.	16.	939.7
1.01	17.20	104	17.33	76.	5.	17.	939.7
1.01	17.30	105	17.50	65.	5.	18.	939.7
1.01	17.40	106	17.67	55.	6.	18.	939.7
1.01	17.50	107	17.83	46.	6.	19.	939.7
1.01	18.00	108	18.00	38.	6.	19.	939.7
1.01	18.10	109	18.17	31.	6.	20.	939.7
1.01	18.20	110	18.33	26.	6.	20.	939.7
1.01	18.30	111	18.50	22.	6.	20.	939.7
1.01	18.40	112	18.67	18.	6.	21.	939.7
1.01	18.50	113	18.83	14.	6.	21.	939.7
1.01	19.00	114	19.00	11.	6.	21.	939.7
1.01	19.10	115	19.17	9.	6.	21.	939.7
1.01	19.20	116	19.33	7.	6.	21.	939.7
1.01	19.30	117	19.50	6.	6.	21.	939.7
1.01	19.40	118	19.67	5.	6.	21.	939.7
1.01	19.50	119	19.83	4.	6.	21.	939.7
1.01	20.00	120	20.00	3.	6.	21.	939.7
1.01	20.10	121	20.17	3.	6.	21.	939.7
1.01	20.20	122	20.33	3.	6.	21.	939.7
1.01	20.30	123	20.50	3.	6.	21.	939.7
1.01	20.40	124	20.67	2.	6.	[illegible]	939.7
1.01	20.50	125	20.83	2.	6.	20.	939.7
1.01	21.00	126	21.00	2.	6.	20.	939.7
1.01	21.10	127	21.17	2.	6.	20.	939.7
1.01	21.20	128	21.33	2.	6.	20.	939.7
1.01	21.30	129	21.50	2.	6.	20.	939.7
1.01	21.40	130	21.67	2.	6.	20.	939.7
1.01	21.50	131	21.83	2.	6.	20.	939.7
1.01	22.00	132	22.00	2.	6.	20.	939.7
1.01	22.10	133	22.17	2.	6.	20.	939.7
1.01	22.20	134	22.33	2.	6.	20.	939.7
1.01	22.30	135	22.50	2.	6.	20.	939.7
1.01	22.40	136	22.67	2.	6.	20.	939.7
1.01	22.50	137	22.83	2.	6.	20.	939.7
1.01	23.00	138	23.00	2.	6.	20.	939.7
1.01	23.10	139	23.17	2.	6.	20.	939.7
1.01	23.20	140	23.33	2.	6.	20.	939.7
1.01	23.30	141	23.50	2.	6.	20.	939.7
1.01	23.40	142	23.67	2.	6.	20.	939.7
1.01	23.50	143	23.83	2.	6.	20.	939.7
1.02	0.00	144	24.00	2.	6.	19.	939.7

1.02	.20	146	24.33	2.	6.	19.	939.7
1.02	.30	147	24.50	2.	6.	19.	939.7
1.02	.40	148	24.67	2.	6.	19.	939.7
1.02	.50	149	24.83	2.	6.	19.	939.7
1.02	1.00	150	25.00	2.	6.	19.	939.7
1.02	1.10	151	25.17	2.	6.	19.	939.7
1.02	1.20	152	25.33	2.	6.	19.	939.7
1.02	1.30	153	25.50	2.	6.	19.	939.7
1.02	1.40	154	25.67	2.	6.	19.	939.7
1.02	1.50	155	25.83	2.	6.	19.	939.7
1.02	2.00	156	26.00	2.	6.	19.	939.7
1.02	2.10	157	26.17	2.	6.	19.	939.7
1.02	2.20	158	26.33	2.	6.	19.	939.7
1.02	2.30	159	26.50	2.	6.	19.	939.7
1.02	2.40	160	26.67	2.	6.	19.	939.7
1.02	2.50	161	26.83	2.	6.	19.	939.7
1.02	3.00	162	27.00	2.	6.	19.	939.7
1.02	3.10	163	27.17	2.	6.	19.	939.7
1.02	3.20	164	27.33	2.	6.	18.	939.7
1.02	3.30	165	27.50	2.	6.	18.	939.7
1.02	3.40	166	27.67	2.	6.	18.	939.7
1.02	3.50	167	27.83	2.	6.	18.	939.7
1.02	4.00	168	28.00	2.	6.	18.	939.7
1.02	4.10	169	28.17	2.	6.	18.	939.7
1.02	4.20	170	28.33	2.	6.	18.	939.7
1.02	4.30	171	28.50	2.	5.	18.	939.7
1.02	4.40	172	28.67	2.	5.	18.	939.7
1.02	4.50	173	28.83	2.	5.	18.	939.7
1.02	5.00	174	29.00	2.	5.	18.	939.7
1.02	5.10	175	29.17	2.	5.	18.	939.7
1.02	5.20	176	29.33	2.	5.	18.	939.7
1.02	5.30	177	29.50	2.	5.	18.	939.7
1.02	5.40	178	29.67	2.	5.	18.	939.7
1.02	5.50	179	29.83	2.	5.	18.	939.7
1.02	6.00	180	30.00	2.	5.	18.	939.7
1.02	6.10	181	30.17	4.	5.	18.	939.7
1.02	6.20	182	30.33	9.	5.	18.	939.7
1.02	6.30	183	30.50	19.	5.	18.	939.7
1.02	6.40	184	30.67	34.	5.	18.	939.7
1.02	6.50	185	30.83	51.	6.	19.	939.7
1.02	7.00	186	31.00	68.	6.	19.	939.7
1.02	7.10	187	31.17	83.	6.	20.	939.7
1.02	7.20	188	31.33	94.	6.	21.	939.7
1.02	7.30	189	31.50	102.	7.	23.	939.7
1.02	7.40	190	31.67	108.	7.	24.	939.8
1.02	7.50	191	31.83	[illegible]	8.	26.	939.8
1.02	8.00	192	32.00	116.	8.	27.	939.8
1.02	8.10	193	32.17	118.	9.	28.	939.8
1.02	8.20	194	32.33	120.	9.	30.	939.8
1.02	8.30	195	32.50	121.	10.	31.	939.8
1.02	8.40	196	32.67	122.	10.	33.	939.8
1.02	8.50	197	32.83	123.	10.	35.	939.8
1.02	9.00	198	33.00	123.	11.	36.	939.8
1.02	9.10	199	33.17	123.	11.	38.	939.8
1.02	9.20	200	33.33	124.	12.	39.	939.8
1.02	9.30	201	33.50	124.	12.	41.	939.9
1.02	9.40	202	33.67	124.	13.	42.	939.9
1.02	9.50	203	33.83	124.	13.	44.	939.9
1.02	10.00	204	34.00	124.	14.	45.	939.9
1.02	10.10	205	34.17	124.	14.	47.	939.9
1.02	10.20	206	34.33	124.	15.	48.	939.9
1.02	10.30	207	34.50	124.	15.	50.	939.9
1.02	10.40	208	34.67	124.	16.	51.	939.9
1.02	10.50	209	34.83	124.	16.	53.	939.9
1.02	11.00	210	35.00	124.	16.	54.	939.9

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.02	11.20	212	35.33	124.	17.	57.	940.0
1.02	11.30	213	35.50	124.	18.	59.	940.0
1.02	11.40	214	35.67	124.	18.	60.	940.0
1.02	11.50	215	35.83	124.	19.	62.	940.0
1.02	12.00	216	36.00	124.	19.	63.	940.0
1.02	12.10	217	36.17	139.	19.	65.	940.0
1.02	12.20	218	36.33	185.	20.	67.	940.0
1.02	12.30	219	36.50	283.	21.	70.	940.0
1.02	12.40	220	36.67	426.	22.	74.	940.1
1.02	12.50	221	36.83	588.	24.	81.	940.1
1.02	13.00	222	37.00	746.	26.	90.	940.2
1.02	13.10	223	37.17	887.	29.	101.	940.2
1.02	13.20	224	37.33	1007.	32.	113.	940.3
1.02	13.30	225	37.50	1106.	36.	127.	940.4
1.02	13.40	226	37.67	1195.	40.	143.	940.5
1.02	13.50	227	37.83	1275.	44.	159.	940.6
1.02	14.00	228	38.00	1344.	49.	176.	940.7
1.02	14.10	229	38.17	1404.	54.	195.	940.8
1.02	14.20	230	38.33	1463.	59.	214.	940.9
1.02	14.30	231	38.50	1528.	66.	233.	941.1
1.02	14.40	232	38.67	1601.	76.	254.	941.2
1.02	14.50	233	38.83	1676.	85.	275.	941.3
1.02	15.00	234	39.00	1745.	95.	298.	941.5
1.02	15.10	235	39.17	1801.	109.	321.	941.6
1.02	15.20	236	39.33	1855.	152.	344.	941.8
1.02	15.30	237	39.50	1955.	197.	368.	941.9
1.02	15.40	238	39.67	2272.	231.	394.	942.1
1.02	15.50	239	39.83	2841.	244.	426.	942.3
1.02	16.00	240	40.00	3610.	262.	467.	942.5
1.02	16.10	241	40.17	4263.	287.	517.	942.8
1.02	16.20	242	40.33	4533.	418.	573.	943.2
1.02	16.30	243	40.50	4450.	611.	628.	943.5
1.02	16.40	244	40.67	4103.	783.	677.	943.8
1.02	16.50	245	40.83	3628.	935.	719.	944.0
1.02	17.00	246	41.00	3126.	1104.	751.	944.2
1.02	17.10	247	41.17	2772.	1232.	776.	944.4
1.02	17.20	248	41.33	2509.	1330.	794.	944.5
1.02	17.30	249	41.50	2293.	1404.	809.	944.6
1.02	17.40	250	41.67	2102.	1458.	819.	944.6
1.02	17.50	251	41.83	1943.	1497.	827.	944.7
1.02	18.00	252	42.00	1811.	1524.	832.	944.7
1.02	18.10	253	42.17	1688.	1539.	835.	944.7
1.02	18.20	254	42.33	1554.	1545.	836.	944.7
1.02	18.30	255	42.50	1379.	1539.	835.	944.7
1.02	18.40	256	42.67	1163.	1521.	831.	944.7
1.02	18.50	257	42.83	935.	1488.	825.	944.7
1.02	19.00	258	43.00	720.	1443.	816.	944.6
1.02	19.10	259	43.17	536.	1387.	805.	944.5
1.02	19.20	260	43.33	391.	1323.	793.	944.5
1.02	19.30	261	43.50	289.	1255.	780.	944.4
1.02	19.40	262	43.67	213.	1185.	767.	944.3
1.02	19.50	263	43.83	156.	1116.	753.	944.2
1.02	20.00	264	44.00	115.	1048.	740.	944.2
1.02	20.10	265	44.17	86.	982.	728.	944.1
1.02	20.20	266	44.33	65.	919.	716.	944.0
1.02	20.30	267	44.50	50.	876.	704.	943.9
1.02	20.40	268	44.67	39.	837.	693.	943.9
1.02	20.50	269	44.83	30.	800.	682.	943.8
1.02	21.00	270	45.00	24.	764.	672.	943.7
1.02	21.10	271	45.17	20.	729.	662.	943.7
1.02	21.20	272	45.33	17.	695.	652.	943.6
1.02	21.30	273	45.50	14.	663.	643.	943.6
1.02	21.40	274	45.67	12.	633.	634.	943.5
1.02	21.50	275	45.83	11.	604.	626.	943.5
1.02	22.00	276	46.00	10.	576.	618.	943.4

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1.02	22.20	278	46.33	9.	524.	603.	943.3
1.02	22.30	279	46.50	9.	499.	596.	943.3
1.02	22.40	280	46.67	9.	476.	590.	943.3
1.02	22.50	281	46.83	9.	454.	583.	943.2
1.02	23.00	282	47.00	9.	433.	577.	943.2
1.02	23.10	283	47.17	9.	413.	572.	943.1
1.02	23.20	284	47.33	9.	394.	566.	943.1
1.02	23.30	285	47.50	9.	376.	561.	943.1
1.02	23.40	286	47.67	9.	358.	556.	943.1
1.02	23.50	287	47.83	9.	342.	551.	943.0
1.03	0.00	288	48.00	9.	328.	547.	943.0
1.03	.10	289	48.17	9.	322.	543.	943.0
1.03	.20	290	48.33	9.	316.	538.	942.9

PEAK OUTFLOW IS 1545. AT TIME 42.33 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1545.	1066.	321.	161.	46585.
CMS	44.	30.	9.	5.	1319.
INCHES		9.26	11.17	11.25	11.25
MM		235.32	293.81	285.75	285.75
AC-FT		528.	637.	642.	642.
THOUS CU M		652.	786.	791.	791.

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RUNOFF SUMMARY, AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES(SQUARE KILOMETERS)

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	4533.	2099.	583.	295.	1.07
		(128.36)(	59.43)(	16.51)(	8.37)(	2.77)
ROUTED TO	2	1545.	1066.	321.	161.	1.07
		(43.74)(	30.18)(	9.10)(	4.55)(	2.77)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	939.60	939.60	942.80
STORAGE	0.	0.	515.
OUTFLOW	0.	0.	283.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.00	944.72	1.92	836.	1545.	8.33	42.33	0.00

1**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

```
1A1             MORRIS LAKE DAM (00306)
 A2             INFLOW HYDROGRAPHY AND ROUTING
 A3             N.J. DAM INSPECTION
 B    290       0      10       0       0       0       0       0       4
 B1     5
 J      1       5       1
 J1    .3      .4      .5      .6      .7
 K      0       1                                       1
 K1 COMPUTE HYDROGRAPH
 M      1       2    1.07       .             .80
 P      0    22.3     112     123     132     142
 T                                                      1     .15
 W2          0.80
 X     -2               1
 K      1       2                                       1
 K1 ROUTING COMPUTATIONS
 Y                              1
 Y1     1                                                      -1
 Y4 939.6     940     941   941.6     942   942.8     943     944     945     946
 Y5     0      19      61     105     226     283     329     912    1790    2889
 $A   157   158.0   160.4   162.8   164.8   165.3   167.7   170.2   172.7
 $E 939.6   940.0   941.0   942.0   942.8   943.0   944.0   945.0   946.0
 $$ 939.6
 $D 942.8
 K     99
 A
 A
 A
 A
 A
1          81/02/18. 12.28.17.     NOS 1.3 - L485.        EL4EPJ6     STANDARD        M AUTO - CYBER 175-3 1007.
```

```
EEEEEEEEEEEE NN        NN DDDDDDDDDD
EEEEEEEEEEEE NN        NN DDDDDDDDDDD
EE           NNN       NN DD       DDD
EE           NNN       NN DD        DD
EE           NNNN      NN DD        DD
EE           NN NN     NN DD        DD
EE           NN  NN    NN DD        DD
EEEEEEEEEEE  NN   NN   NN DD        DD
EEEEEEEEEEE  NN    NN  NN DD        DD
EE           NN     NN NN DD        DD
EE           NN      NNNN DD        DD
EE           NN       NNN DD        DD
EE           NN       NNN DD        DD
EE           NN        NN DD       DDD
EEEEEEEEEEEE NN        NN DDDDDDDDDDD
EEEEEEEEEEEE NN        NN DDDDDDDDDD
```

```
EE              CC              HH         HH 00            00
EE              CC              HH         HH 00            00
EE              CC              HH         HH 00            00
EE              CC              HH         HH 00            00
EEEEEEEEEEE     CC              HHHHHHHHHHHHH 00            00
EEEEEEEEEEE     CC              HHHHHHHHHHHHH 00            00
EE              CC              HH         HH 00            00
EE              CC              HH         HH 00            00
EE              CC              HH         HH 00            00
EE              CC              HH         HH 00            00
EE              CCC          CC HH         HH 000          000
EEEEEEEEEEEE     CCCCCCCCCC     HH         HH   0000000000
EEEEEEEEEEEE       CCCCCCCC     HH         HH    00000000
```

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1**********************************
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION      JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********************************
1                                PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                                         RUNOFF HYDROGRAPH AT          1
                                         ROUTE HYDROGRAPH TO           2
                                         END OF NETWORK

1**********************************
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION      JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********************************

 RUN  DATE# 81/02/18.
      TIME# 12.28.51.

                                     MORRIS LAKE DAM (00306)
                                     INFLOW HYDROGRAPHY AND ROUTING
                                     N.J. DAM INSPECTION

                                                  JOB SPECIFICATION
                    NQ       NHR      NMIN      IDAY       IHR      IMIN     METRC      IPLT      IPRT     NSTAN
                   290         0        10         0         0         0         0         0         4         0
                                              JOPER       NWT     LROPT     TRACE
                                                  5         0         0         0

                                            MULTI-PLAN ANALYSES TO BE PERFORMED
```

```
                    RTIOS=    .30    .40    .50    .60    .70

       **********        **********        **********        **********        **********

                                    SUB-AREA RUNOFF COMPUTATION

              COMPUTE HYDROGRAPH

                         ISTAQ    ICOMP    IECON    ITAPE    JPLT    JPRT    INAME    ISTAGE    IAUTO
                             1        0        0        0       0       0        1         0        0

                                        HYDROGRAPH DATA
              IHYDG     IUHG    TAREA    SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
                  1        2     1.07    0.00     1.07      .80    0.000        0        0        0

                                         PRECIP DATA
                    SPFE      PMS       R6      R12      R24      R48      R72      R96
                    0.00    22.30   112.00   123.00   132.00   142.00     0.00     0.00

                                          LOSS DATA
         LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
             0    0.00    0.00    1.00    0.00    0.00    1.00    1.00     .15    0.00    0.00

                                       UNIT HYDROGRAPH DATA
                                   TC=  0.00     LAG=   .80

                                          RECESSION DATA
                          STRTQ=    -2.00     QRCSN=     0.00     RTIOR= 1.00

           0                                END-OF-PERIOD FLOW
   MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q     MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP Q

                                                                   SUM  25.33  20.55   4.79    85641.
                                                                      ( 643.)( 522.)( 122.)( 2425.08)

       **********        **********        **********        **********        **********

                                        HYDROGRAPH ROUTING

              ROUTING COMPUTATIONS

                         ISTAQ    ICOMP    IECON    ITAPE    JPLT    JPRT    INAME    ISTAGE    IAUTO
                             2        1        0        0       0       0        1         0        0
                                              ROUTING DATA
                  QLOSS    CLOSS      AVG     IRES    ISAME    IOPT    IPMP              LSTR
                    0.0    0.000     0.00        1        0       0       0                 0

                         NSTPS    NSTDL      LAG    AMSKK        X      TSK    STORA    ISPRAT
                             1        0        0    0.000    0.000    0.000       0.       -1

  STAGE       939.60      940.00      941.00      941.60      942.00      942.80      943.00      944.00      945.00      946.

   FLOW         0.00       19.00       61.00      105.00      226.00      283.00      329.00      912.00     1790.00     2889.00

 SURFACE AREA=      157.        158.        160.        163.        165.        165.        168.        170.        173.

     CAPACITY=        0.         63.        222.        384.        515.        548.        714.        883.       1055.

    ELEVATION=      940.        940.        941.        942.        943.        943.        944.        945.        946.
```

```
            939.6      0.0       0.0       0.0       0.0       0.0       0.0       0.0

                                          DAM DATA
                                  TOPEL    COQD    EXPD   DAMWID
                                  942.8     0.0     0.0      0.

PEAK OUTFLOW IS      104. AT TIME  43.33 HOURS

PEAK OUTFLOW IS      236. AT TIME  43.17 HOURS

PEAK OUTFLOW IS      278. AT TIME  43.17 HOURS

PEAK OUTFLOW IS      477. AT TIME  43.00 HOURS

PEAK OUTFLOW IS      722. AT TIME  42.83 HOURS


          **********          **********          **********          **********          **********

1
          PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                      FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
                             AREA IN SQUARE MILES (SQUARE KILOMETERS)

                                                               RATIOS APPLIED TO FLOWS
OPERATION      STATION       AREA      PLAN   RATIO  1   RATIO  2   RATIO  3   RATIO  4   RATIO  5
                                                   .30        .40        .50        .60        .70

HYDROGRAPH AT        1        1.07        1     1360.      1813.      2266.      2720.      3173.
                   (       2.77)         (    38.51)(    51.34)(    64.18)(    77.01)(    89.85)(

ROUTED TO            2        1.07        1      104.       236.       278.       477.       722.
                   (       2.77)         (     2.94)(     6.67)(     7.87)(    13.51)(    20.44)(
1
                                                  SUMMARY OF DAM SAFETY ANALYSIS

     PLAN  1 ...............             INITIAL VALUE      SPILLWAY CREST      TOP OF DAM
                            ELEVATION        939.60              939.60            942.80
                            STORAGE              0.                  0.              515.
                            OUTFLOW              0.                  0.              283.

                 RATIO     MAXIMUM     MAXIMUM     MAXIMUM     MAXIMUM    DURATION      TIME OF      TIME OF
                   OF     RESERVOIR     DEPTH      STORAGE     OUTFLOW    OVER TOP   MAX OUTFLOW    FAILURE
                  PMF     W.S.ELEV    OVER DAM      AC-FT        CFS        HOURS        HOURS        HOURS

                  .30      941.58       0.00        316.        104.        0.00        43.33         0.00
                  .40      942.14       0.00        406.        236.        0.00        43.17         0.00
                  .50      942.73       0.00        503.        278.        0.00        43.17         0.00
                  .60      943.25        .45        590.        477.        4.67        43.00         0.00
                  .70      943.67        .87        660.        722.        6.67        42.83         0.00
1**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION   26 FEB 79
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APPENDIX 4

NOTES ON NEWTON, NEW JERSEY WATER WORKS
CONSTRUCTION AND LITIGATION

NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XXIII. June, 1909. No. 2.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

NOTES ON NEWTON, N. J., WATER WORKS CONSTRUCTION AND LITIGATION.

BY LOUIS L. TRIBUS, MEMBER AMERICAN SOCIETY CIVIL ENGINEERS; MEMBER NEW ENGLAND WATER WORKS ASSOCIATION.

[Read December 9, 1908.]

In 1894 the town of Newton, situated in the semi-mountainous region of the northwestern part of New Jersey, took up very actively the question of a public water supply. Rain water cisterns, shallow dug wells penetrating slightly into the slate rock, and an occasional driven or bored well but partially served the general needs of the community. An active contest was waged between interests desiring municipal ownership and those either wishing to secure a franchise or preferring that one be granted.

Early in the proceedings the writer was called upon to advise various committees, and later, when final decision called for municipal construction, to design the works and carry them to completion, and from time to time since then, to take up matters of operation and litigation.

Three sources of supply seemed possible: first, a driven-well pumping system close to the town, but subject to risk of contamination as the town developed; second, a lake of rather hard water, some four miles away, for which, also, pumping would be necessary. The third, recommended by the writer, and finally adopted, was Morris Lake, situated about eight miles in an air line from Newton, in depth from eight to one hundred and ten feet, somewhat increased over natural capacity by a low dam, and the

NOTE. — Among the illustrations in this paper occur a number reproduced through the courtesy of the *Engineering Record.*

surface at such an elevation as to permit of a flow by gravity and give a good serviceable pressure in all parts of Newton except one small high point and a portion of another hill lying chiefly outside the town limits. (Fig. 1.)

The source of supply thus selected was well-nigh ideal; a soft water; an uninhabited, mountainous, 85 per cent. wooded watershed (Fig. 1, Plate I). Unfortunately, however, for legal reasons, the lake was not tributary to a stream passing the town of Newton, but to one flowing in a different direction, so that Newton had no standing as a riparian owner.

The writer urged very strongly upon the Water Commissioners an amicable settlement with the mill owners on the stream below the lake before any work should be carried out, a settlement that could have been readily effected for a few hundred dollars apiece, probably not aggregating over two thousand dollars at the outside. Coupled with that advice it was still deemed advisable to provide increased storage facilities in Morris Lake, so that from storm flows alone there could be impounded an abundance of water for the needs of the town and thereby not interfere with the normal ordinary flow from the lake.

To this latter end a small brook, not entering the lake, but joining its outlet, far above the first mill (Titman's), was diverted by a masonry head gate (Fig. 2, Plate I) into a side hill ditch or canal (Fig. 1, Plate II) some three thousand feet or so in length, reaching a point just above the masonry dam, which was constructed at the outlet of the lake proper, at a site almost perfect for the purpose — a narrow neck with rock sides and bottom. To provide the additional storage, the dam was constructed of such a height as to raise the normal level of the lake about five feet, giving a flooded area of 155 acres, and in addition flash boards could be placed in the spillway, adding another two feet if desired. The total storage above the lower outlet thus secured amounted to 730 000 000 gallons, while the storage above the original normal high-water mark amounted to 208 000 000 gallons (Fig. 2, Plate II, and Fig. 1, Plate III).

As the combined watersheds thus made available equaled about three and one-half square miles, the estimated draft of 1 000 000 gallons per twenty-four hours could be easily provided several

Fig. 1.

NEWTON N.J. WATER WORKS

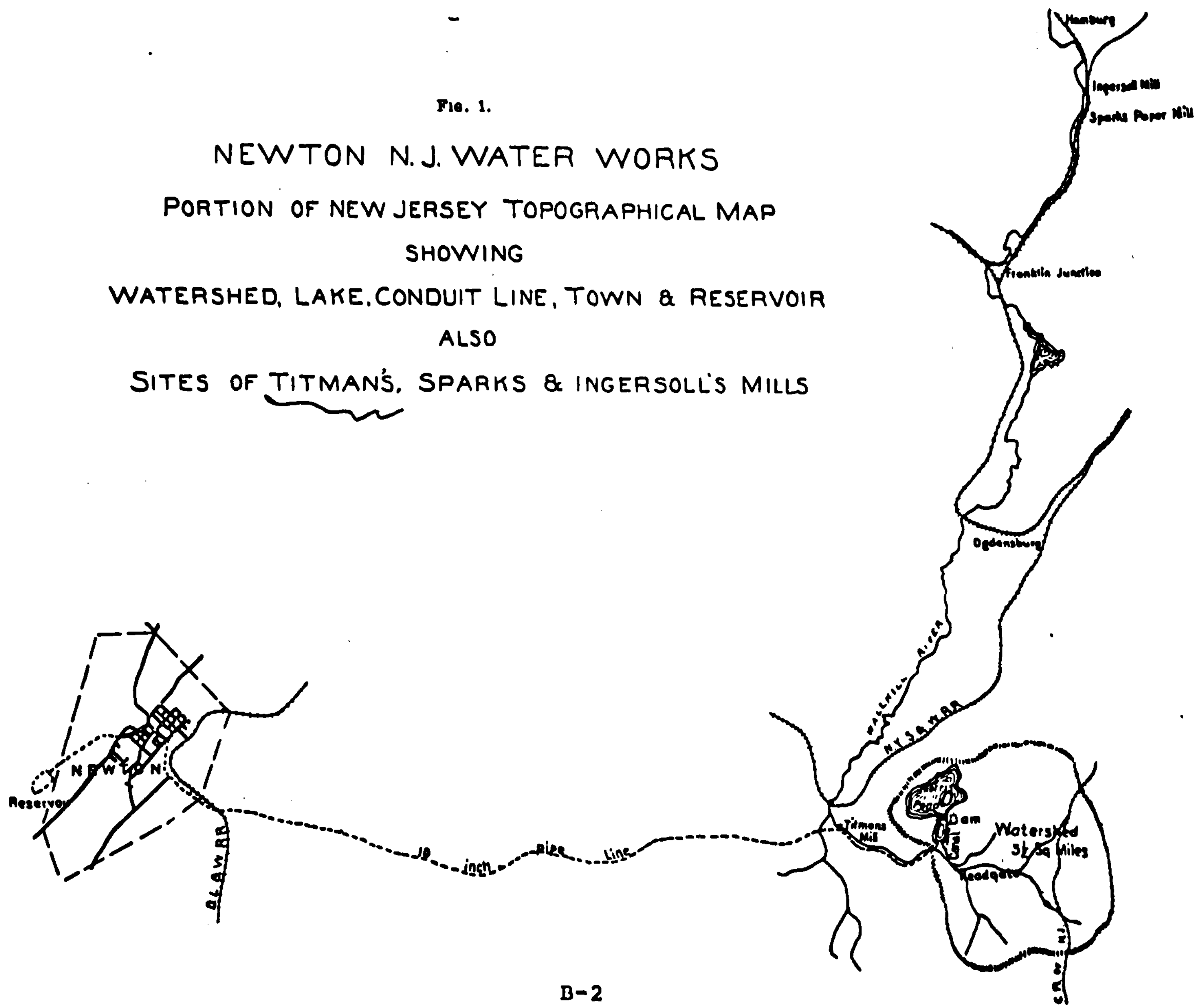
PORTION OF NEW JERSEY TOPOGRAPHICAL MAP

SHOWING

WATERSHED, LAKE, CONDUIT LINE, TOWN & RESERVOIR

ALSO

SITES OF TITMAN'S, SPARKS & INGERSOLL'S MILLS



times over during the year from storm waters, which could not have been used through any existing developments by any mill on the stream (a tributary of the Wallkill River).

The Water Commission purchased the fee in Morris Lake (though not in the pond below the lake) and in a sufficient strip surrounding it to give reasonable protection and access; but in purchasing some of the land owned by the mill owner (J. B. Titman) next below the lake there was reserved to him the right to operate the gates in the artificial pond at the outlet of the main lake that had been in existence for many years and which because of the breaking down of an old dam between them had been, for a period, a part of it.

In the agreement, the town also bound itself to open the gate in the masonry dam so as to keep up the water level in the lower pond, thus practically leaving the control of the outflow in the hands of Titman, who had first right to use the waters, and who for many years had thus used the outflow from the lake and pond as he chose, without reference to any mill owners further down stream. Those lower owners had no pondage to do other than to steady the head upon their water wheels and, consequently, could not regulate the flow of the stream to any real extent for their own benefit, and also they had no special rights in the lake's storage or in control of its outflow.

Construction was carried on as previously outlined, without any formal objection from any mill owner. As a matter of fact, the mills were greatly benefited by the work done, for by the conservation of the storm waters, in excess of those which Newton could use, the stream flow was steadied, thus better meeting the needs of the mills than was possible prior to the construction.

The Water Commission did not take the advice of its engineer as to making agreements with the different mill owners, so that after the work was completed and the town was being supplied with water, several suits for damages for diversion of water were instituted, and these suits were pressed to final decision, the court of last resort, that of Errors and Appeals, confirming the decision of the Court of Chancery as to the principle involved, that payment must be made in money, as liquidated damages, instead of in kind, with water, but reversing the decision as to amount of

awards, cutting them down from $3 180 to $500 in one case, and from $3 962.40 to $750 in the other. The whole litigation, however, entailed an expense upon the town many times greater than would have been the case if preconstruction agreements had been entered into.

Early in 1902, J. B. Titman, the mill owner from whom the town had purchased some lands and rights, and to whom the privilege of gate opening had been accorded, as before noted, also brought suit for damages.

After litigation lasting several months, involving the attendance at the trials of many witnesses (experts and others), the case was compromised out of court by the town agreeing to pay said Titman $5 500, receiving in return full control of the lake and Pine Swamp Brook (the one diverted to augment the Morris Lake supply) and use of all water which could flow through the existing 10-inch pipe line to Newton, and further agreeing to be careful in letting out the surplus lake waters, so as not to cause injury to the dam at lower end of pond adjoining the lake, and also to permit Titman to raise said earth dam up to within 4 feet of the level of the spillway in the masonry structure erected by the town.

Fig. 2, Plate III, shows the wastage of water from Titman's mill and the extravagant drafts he made on the stream and stored waters, after he contemplated bringing suit for damages, trying to create a shortage in storage, and show his great deprivation of water, presumably due to the town's use of it.

The main pipe line, 10 inches in diameter, was laid on an acquired right of way in as nearly as possible an air line, two or three summits being encountered, as may be noted on the profile (Fig. 2), where air valves were deemed advisable. At one place the summit

FIG. 2.

PLATE I.

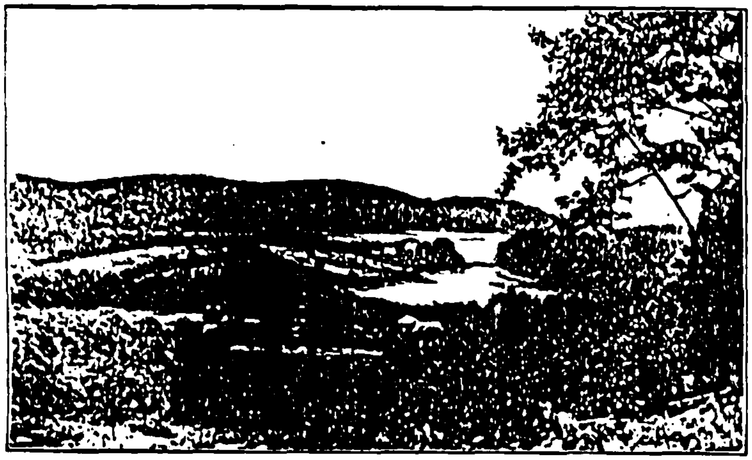


FIG. 1.

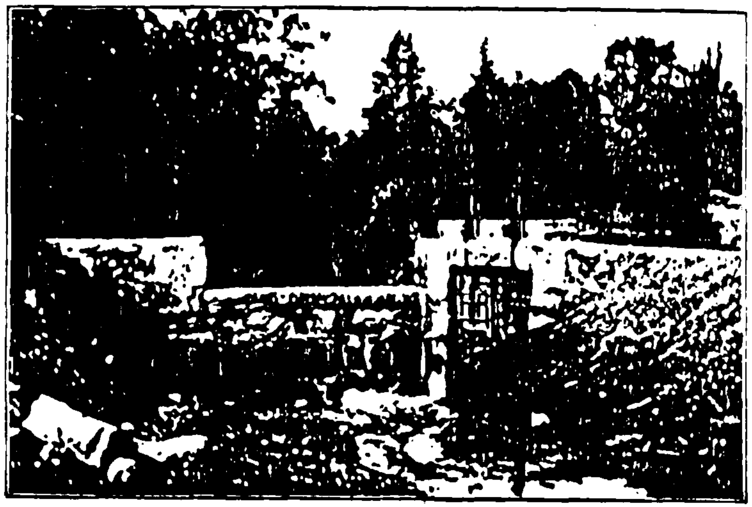


FIG. 2.

PLATE II.

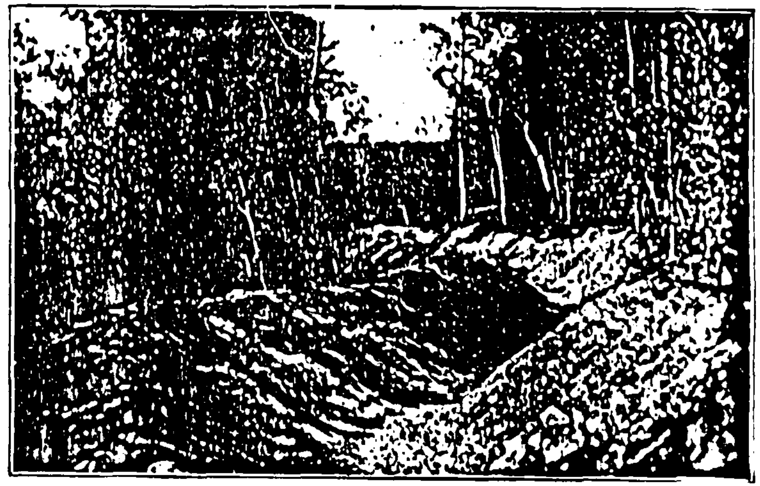


FIG. 1.

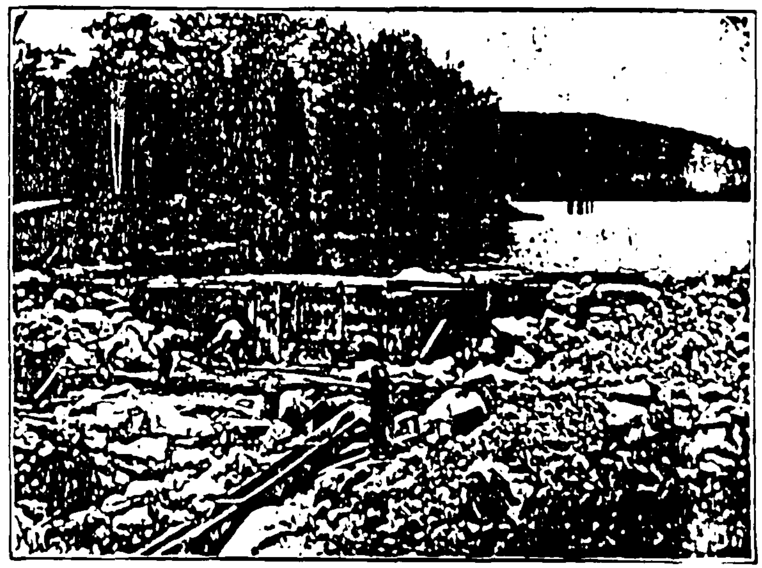


FIG. 2.

PLATE IV.

FIG. 1.

FIG. 2.

PLATE III.

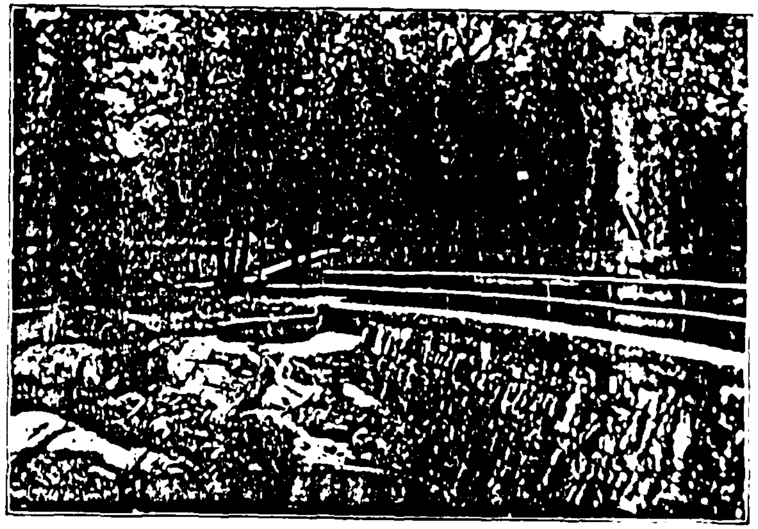


FIG. 1.

FIG. 2.

so nearly approached the hydraulic grade line (taking the elevation of assumed average draft), as to become the controlling factor in the calculated flow of the main, as brought out in the court proceedings. The writer protested against laying any main less than 12 inches in diameter and urged the securing of rights of way, for later duplicating the line, if necessary, but the commissioners in their wisdom thought the ten or twelve thousand dollars' extra cost of the larger pipe prohibitive and the securing of additional rights unnecessary. Time has already demonstrated the wisdom of the engineer's advice, for the 10-inch main is well-nigh overtaxed, and needed rights for another main will require additional payments, while the water for the extra draft will have to be paid for by a new crop of damage suits, or through agreements to be entered into prior to its construction.

Though contemplated in the original scheme, the reservoir in the town was not constructed until 1905, when the draft had increased to such an extent as to make a twenty-four-hour flow necessary. This reservoir provides in its six or seven million gallons storage some little reserve in case of pipe line accident or stoppage, and secures a steadier fire service (Fig. 1, Plate IV).

DETAILED DESCRIPTION OF PLANT.

The two lakes meet at a narrow strait, having a rock bluff at one side and a sloping rock ledge on the other. An old crib dam had formerly been in use, but years ago it was partially demolished. The rock banks met at a point 30 feet below the new high-water mark, or 33 feet below the top of the masonry, without injurious seams or cracks. The site could not have well been more advantageous, enabling a dam to be built only 150 feet long on the crest, with but 25 feet of it having any considerable depth.

Fig. 3 shows the general plan of headgate, canal, pond, lake, standpipe, and submerged outlet conduit.

The head-gate works for controlling the diversion canal consist of a small masonry dam and overflow weir, having two 24-inch gates opening into the canal. These openings will pass all of the normal and much of the flood season flow of the stream, and are located on Pine Swamp Brook about three thousand feet from and fourteen feet above the upper lake.

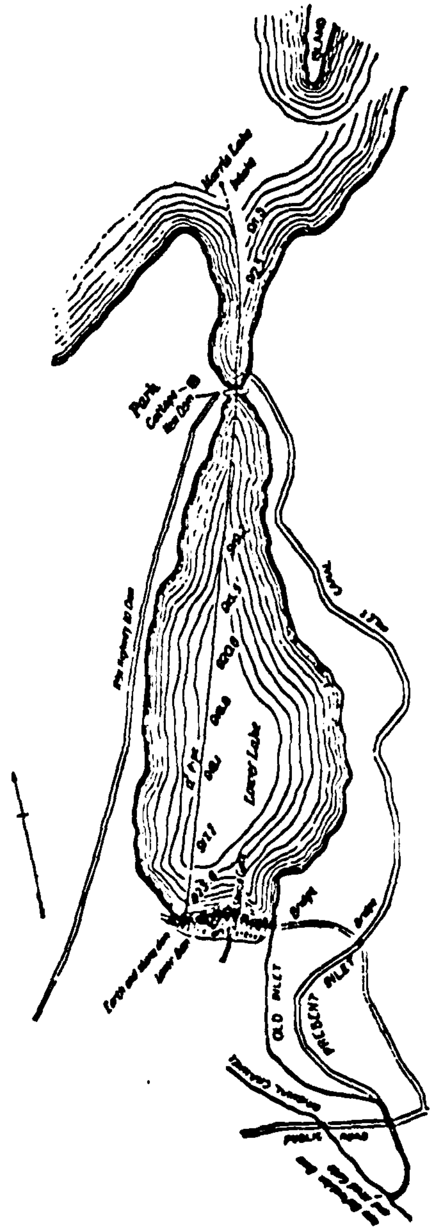


FIG. 3.

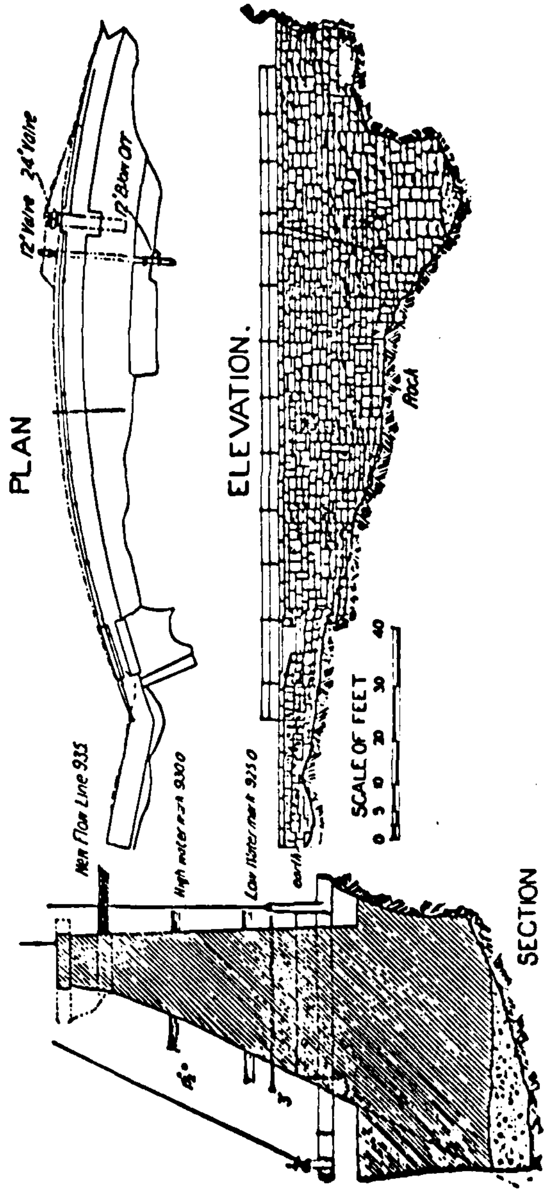
The deflection canal is 3,000 feet in length, following the general contour of the hill. It is 4 feet wide at the bottom, 2½ feet deep to the water run, and has slopes of 1½ to 1 in earth and ½ to 1 in rock. The canal was constructed in excavation entirely, so that the water run is everywhere in natural ground; the grade is 5 inches per 100 feet.

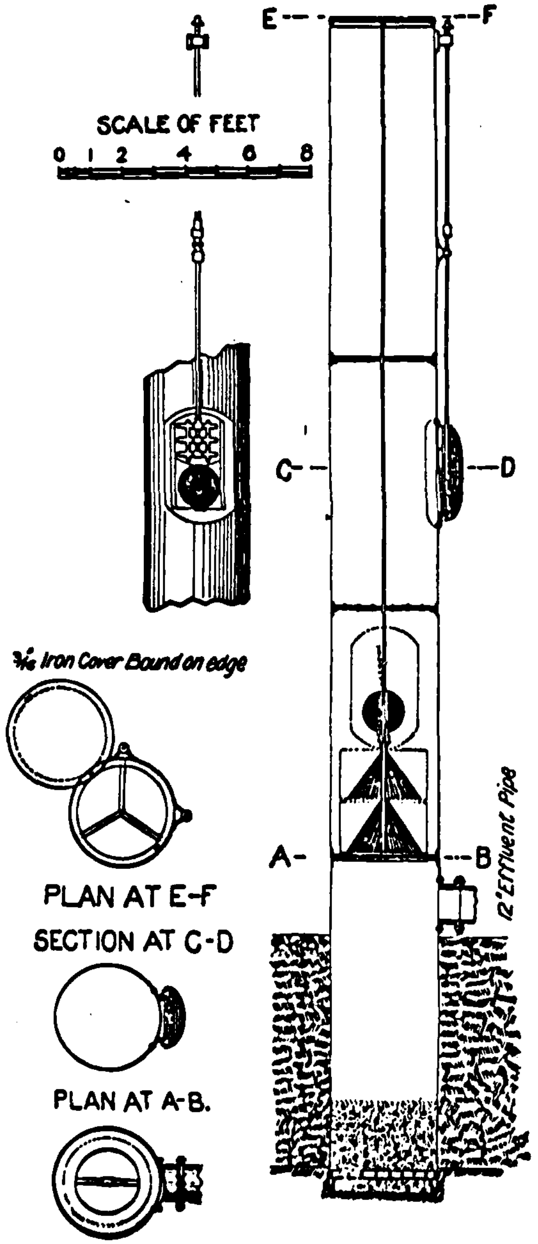
A timber cofferdam, about eight feet in width by nine feet in depth by sixty feet in length, was first built across the strait, 15 feet above the toe of the new dam, inclosing the end of the 12-inch effluent pipe, and provided with a 12 by 12-inch sluice to draw off water for the mills, if required. It was heavily framed, planked on both sides, its bottom shaped to the contour of the lake bed, steadied in place, and still further tightened by a double row of sheet piling driven to hard bottom. Clay and sand filling inside and on the upper lake side made a very tight structure, so that when the lower lake was drawn off and all the pressure came on one side, hand-pumping readily cared for all the seepage.

The main dam was constructed of local stone, a species of granite, laid as rough rubble, with rough dressed copings and spillway, the sand for cement mortar being fine crushed rock from the Edison ore crushing works (Fig. 4). The flow line without flash boards was established at elevation 935 feet above sea level.

Adjoining the site of the dam, about five acres of land was secured for park purposes, and a commodious cottage was erected for the superintendent in charge of lake and conduit.

The conduit line is supplied through an intake standpipe in the lake and a submerged main carried along the bottom of the upper pond, through the masonry impounding dam and along the entire length of the lower pond and through the old dam at its lower end. The intake standpipe consists essentially of a wrought-iron open-ended cylinder 3½ feet in diameter and 38 feet in height, furnished with two 16-inch sluice gates opening at elevations 915½ and 922½, with conical brass screens inside, and connected with the 12-inch effluent pipe at elevation 912½. (Fig 5.) It was made with a reinforced cutting edge in the bottom and is protected by eight piles with cross and diagonal bracing of timber and sheathing, and some one hundred and fifty loads of riprap dropped around the foot.





Early in January, 1895, the ice having reached 12 inches in thickness, a point was selected (previous soundings having determined the approximate locality) where the silt bottom was 10 feet thick, and hard bottom found at elevation 900. A 40-foot derrick was then erected on the ice, its load distributed by a large plank platform, and the standpipe, bolted together, was raised complete, with 72 feet of 12-inch main attached, and lowered to position through a hole cut for it and a channel for the pipe. Its weight (about eight tons) caused it to sink several feet in the silt, cutting its way through; then by dredging from the inside and weighting, it was sunk into the hard bottom. When all the silt had been removed from the inside, Portland cement concrete was rammed in to a depth of 4 feet, giving additional stability and effectually shutting out all infiltration of silt. The piles were at once placed in similar manner with the derrick, and driven by it also, using a 1 500-pound hammer, with an 8-foot drop, guided by a scantling frame around the hammer long enough to pass down over the pile.

While the standpipe was being lowered, 72 feet of the 12-inch main connected to it was lowered also, in water 20 feet in depth, keeping the free end on top of the ice. To this was attached section after section, 48 feet being thereafter lowered at a time. A Ward spherical joint every 48 feet gave motion enough and rope supports in between kept the sections rigid, until they rested finally on the bottom. The upper lake section was 650 feet in length through the cofferdam. The lower lake section was about fourteen hundred feet to the lower earth dam. The depths ranged from six to twenty feet of water and zero to ten feet of silt. The work itself was very easily done, it being necessary simply to lay the pipe in a straight line on the ice, connect it up with lead joints, make a saw cut through the ice on each side of the line, the ice being from ten to fourteen inches in thickness, and lower the main gradually until it reached bottom, 48 feet at a time. At a later date when, during construction of the dam, the lower lake was emptied, the pipe was found resting easily, with no indications of break or strain. (Fig. 2, Plate IV.) It was thought best then to lower it from two to four feet to provide for a future complete draining of the lower lake, which was done by excavating underneath it and letting it settle.

The whole plant (including distribution system) was put in operation October 1, 1895, and was received from the commissioners by the town of Newton on October 17, 1895. The principal other dates of note were as follows:

December 3, 1894: contracts for

(*a*) Pipe and specials to Warren Foundry and Machine Company.

(*b*) Valves and hydrants to Eddy Valve Company.

(*c*) Intake standpipe to Tippett & Wood.

December 18, 1894: contract for construction awarded to Smith & McCormick, of Easton, Penn.

January 14, 1895: construction begun.

May 8, 1895: contract for highway and bridge to B. H. Titman.

August 31, 1895: water turned into main pipe line.

September 19, 1895: water turned into canal, practically completing the construction period.

Officials connected with the work of construction:

Water Commissioners: Hiram C. Clark, president; Alex. Craig, secretary; A. J. Van Blarcom, treasurer.

Counsel: Chas. M. Woodruff.

Engineers: Louis L. Tribus, chief; Andrew H. Konkle, assistant on preliminary surveys; Chas. G. Massa, assistant on construction, lake division; B. F. Ward, assistant on pipe lines.

The work was completed within contract time, without material deviation from the plans and specifications, and for a total sum about one and a half per cent. less than the engineer's original estimate, the whole plant, without litigation, costing about one hundred and five thousand dollars for rights, lands, construction, supervision, and miscellaneous expenses.

The writer has thought the litigation to be of sufficient interest to warrant the presentation, not of the testimony given, but of the full decision of the court of last resort, which reviewed briefly the facts and gives clearly the argument and dictum:

New Jersey Court of Errors and Appeals, November Term, 1899. The Sparks Manufacturing Company, Respondent, *v.* The Town of Newton, Appellant; Worthington H. Ingersoll, Respondent, *v.* The Town of Newton, Appellant.

(1) When the riparian proprietor seeks the aid of a court of equity to restrain the diversion of water by a municipal corporation for public purposes, and offers to forego his right to an injunction on recovering just compensation, which he asks the Court to determine, and the defendant in its answer consents to pay such compensation so as to be determined by the Court, in case the Court considers the complainant entitled to an injunction, the Court has jurisdiction to ascertain the amount of such compensation.

(2) A municipality which buys a piece of land on a private stream several miles from its corporate limits does not thereby become entitled as riparian owner to draw from the stream a supply of water for the inhabitants of the town.

(3) The town of Newton has no authority to divert water from private streams, to the detriment of lower riparian owners, on condition that it will store storm water and give it out into the streams in dry times, and thus confer a compensatory benefit on those owners, they not consenting thereto.

(4) In ascertaining just compensation for the diversion of water from a mill, the difference between the market value of the mill before the diversion and its market value afterwards is usually a simpler and safer criterion than estimates of the probable cost of producing by steam at the mill the power which the diverted water would supply and then estimates of the probable value of the water power at the mill, based on the rental value of power at other places more or less distant and dissimilar.

Messrs. W. H. and C. L. Corbin for complainants, respondents; Mr. Thomas Kays for defendant, appellant.

The opinion of the Court was delivered by Dixon, J.

The circumstances of these cases are very fully stated in the preface and opinion of Vice-Chancellor Pitney, 57 N. J. Eq. 367. With the conclusion there expressed touching the power and duty of the Court, on the pleadings and evidence, to fix the compensation that the defendant ought to pay to the complainant as a condition of withholding the injunctions to which they otherwise would be entitled, this Court agrees. Only with respect to the amount awarded do we find reason for dissent.

The right to be obtained by the defendent under these decrees is the right to abstract from one of the tributaries of the Wallkill River a definite quantity of water, which in its natural course would flow past the complainant's mills. The opinion of the vice-chancellor deals with the right to divert 800 000 gallons per day, and this quantity of water is shown by him to be capable of producing 2.54 continuous horse-power at the Sparks Company's mill and 2.05 continuous horse-power at Ingersoll's mill. On this basis the learned vice-chancellor proceeds with two calculations:

(1) To ascertain the probable annual cost of producing the same power by steam at these mill sites, and (2) to ascertain the probable annual value of the power at these localities, in view of the rental price of such power in other places more or less distant and dissimilar. Having thus formed an estimate of the annual value of the power, he compounds that value at 4 per cent. for forty years and finds the present value to be $3 302 at the Sparks mill and $2 650 at the Ingersoll mill, and, therefore, awards these sums.

In this course of reasoning little, if any, attention was paid to the actual market value of the mill sites, and yet in Packard *v.* Bergen Neck R. R. Co., 25 Vroom, 553, this Court declared that, when only part of a person's property is taken, just compensation will be made by awarding the difference between the market value of the property before any part was taken and the market value of the property after the taking.

While it may be proper in such cases as the present to take into consideration the matters on which the vice-chancellor's award rests, still we deem the difference between market values a simpler and safer criterion; and when it appears that by following other guides a result is reached utterly irreconcilable with this criterion, that result cannot be sustained. That such incompatibility exists in the case before us will be made manifest by a few considerations now to be stated.

The testimony of witnesses living in the neighborhood of the Ingersoll mill and familiar with it for many years is to the effect that the fair market value of the whole plant in 1896 when these bills of complaint were filed was $5 000 or $6 000. It has a total capacity to use 132 horse-power of water, which will be furnished by about 1 100 000 000 gallons of water per month. A tabulated statement of the natural flow of the river at Ingersoll's mill, known in the case as Vermeule's Table D, which appears to have been accepted as trustworthy by all parties at the trial, shows that during eight months of the average year there is more than a sufficient supply of water for the full capacity of the mill, that during June and September the supply is above five sixths of the capacity, and that during July and August the supply exceeds five ninths of the capacity. These data indicate an annual supply equivalent to 118 continuous horse-power at this mill.

Now, if for the abstraction of 2.65 continuous horse-power the mill owner ought to be paid $2 650, then, for the abstraction of the whole power he ought to be paid $118 000. Such an inference proves the extravagance of the award. In April, 1896, the plant of the Sparks Manufacturing Company was purchased by that

company for $75 000. The plant included the water machinery with a total capacity of 170 horse-power, steam machinery having 100 horse-power, mill buildings, and several acres of land.

To run the water plant to its full capacity the company required about 1 360 000 000 gallons of water per month, and beside it used about 30 000 000 gallons per month for condensing steam, washing fabrics, etc. Vermeule's Table D shows that during eight months of the average year there is more than a sufficient supply of water for the full capacity of this water power, that during June and September the supply is about two thirds of the capacity, and that during July and August the supply is about four ninths of the capacity. These data indicate an annual supply equivalent to 141 continuous horse-power at this mill.

If for the abstraction of 2.54 continuous horse-power of water the company ought to be paid $3 302, then for the abstraction of the whole power it ought to be paid $183 300. This inference proves the extravagance of the Sparks Company's award.

We think there is another error in the basis on which the present awards are made. Assuming that the defendant withdraws 800,000 gallons of water per day (i. e., 25 000 000 gallons per month), Vermeule's Table D shows that in an average year after the allowance to the defendant is taken, more water will flow past these mills during eight months than either of the mills can utilize, so that only during four months will the supply available in the mills be perceptibly diminished. During these months the water diverted by the town would furnish 3 horse-power at the mills, and 3 horse-power for four months would be equivalent to 1 continuous horse-power. Thus, even on the assumption that water power at these mills is as valuable as the learned vice-chancellor deemed it to be, allowances for 2.54 and 2.65 continuous horse-power are about two and one-half times too large.

In our judgment an award of $500 to Mr. Ingersoll and of $750 to the Sparks Manufacturing Company will afford ample compensation to them for the abstraction by the defendant of 800 000 gallons of water per day. Under the election by the town to abstract 1 250 000 gallons per day, these sums must be proportionately increased.

Let the present decree be reversed and decrease be rendered in accordance with the judgment above stated.

Notwithstanding this very lucid decision, the writer still holds very clearly to his belief that true justice should refuse to award damages where no actual damage has occurred or can occur, and where real benefit has been created instead. That argument is, of course, met by the actual fact that water was diverted, so that theoretically the mills were deprived of it, and in light of a constitutional and not parliamentary government, payment can only be made in coin of the realm and must be based on theoretical as well as real injury.

Newton's case was at the time almost unique in the United States, where works of benefit were actually completed and in operation before litigation was begun, so that real damage could not be proven by inference or be shown in fact.

DISCUSSION.

MR. CHARLES E. CHANDLER. At one or two meetings of the New England Water Works Association the question of compensating for diversion in kind, recommended in Norwich by Hill, Quick & Allen, has been referred to. I will read five or six lines which describe just the method in which Hill, Quick & Allen suggested that riparian owners be compensated for water that might be taken by the city. The proposition was to build a large storage reservoir, large enough to be ample for the city's needs with something left for the mill owners, but the actual proposition reads a little differently:

"Whenever the flow of the Yantic River at any of the mills from the watershed of that river above the mills, exclusive of the 11.9 square miles on Pease Brook, is less than the amount necessary to develop the flow at the mill, water is to be released from the proposed storage reservoir for the benefit of all the mills in quantities equal to the estimated flow of Pease Brook, at that time, but not exceeding the amount of the above deficiency."

That is the whole plan and, as you will see, it does not call for compensating the mills at all, but calls for a delivery to the mills, every day when they are short of water, the exact amount of water, as nearly as can be ascertained, that they would have received if this reservoir had not been built. The mill owners took it into consideration, and, having decided that the plan wasn't likely to go through for other reasons, declined to consider the proposition at all.

MR. WILLIAM S. JOHNSON. There was a case which interested

me very much, and it may interest water-works officials, which came up a few days ago, where a manufacturing company in a certain town was sued by the town for water rates, it being alleged that the company had been stealing water from the department. The result of that suit was that the town was obliged to pay the manufacturing company $100 and court expenses. That seems a little peculiar, but the fact was that the water which had been furnished by the town to the manfacturing company had never been legally taken, but was being practically stolen from the manufacturing company, so you see there the tables were turned. This story carries its own moral.

VICE-PRESIDENT KING. The city of Taunton has had a case very similar to the one of which Mr. Tribus has spoken, and it was on trial last week. In 1875 an act of the legislature was passed which allowed the city of Taunton to take water from the Taunton River or from the Lakeville ponds. We first took it from the Taunton River, and in 1894 we went to the Lakeville ponds for water. The act of 1875 allowed us to take water from the Assowompsett Pond, but only the "surplus waters" of that pond, and required us to build a dam at the outlet, not less than two and one-half feet in height, — that is, there was an old mud sill there and this dam must be at least two and one-half feet above that old mud sill, — and we might store water for one year's supply of the city of Taunton, but we must maintain the natural flow of the stream.

There were some rather peculiar terms in the act. What the natural flow of the stream is it is hard to express; I suppose, in one sense that the natural flow is all the water that runs down that stream, but the Supreme Court has passed upon the act (166 Mass. 540) and said that it couldn't say just what the words meant, but that the intent was that we should let down during the dry season as much water as usually went down there, and we might store and use the water which came from thaws, freshets, and recent heavy rains.

The town of Middleboro owns part of the first water privilege below the lake, from which they get power to furnish electricity for the town of Middleboro. We took this water in July, 1894, and within a year they brought an action against us for diversion.

For eight years the suit was carried on the court records and no action taken by the town to bring the case to trial. In 1903 they began to move to get their money. The first action was heard by the county commissioners of Plymouth, and the city put in no defense, our attorney claiming that the town had not made out a case. The town put in its evidence and the county commissioners awarded $2 000 damages. From this award the city of Taunton appealed.

A year or two afterwards Marcus Morton, Esq., of Boston, was appointed auditor by the court, and heard the case.

There is a little peculiarity in the deed of the water power to the town of Middleboro. The town is entitled to the use of the first 75 horse-power in that stream. If there is anything above that, I suppose that it is entitled to what it can get from the stream, but more than half of the dam belongs to some one else. There are two or three other opportunities to draw water, so that the amount of water the town could get over the 75 horse-power to which it is entitled would probably be small.

The auditor found that Taunton does not damage Middleboro if it is entitled to only 75 horse-power. If it is entitled to what they claimed, 125 horse-power (which was the development of their wheels), and if Taunton could operate its dam adversely to the interests of Middleboro, he estimated the damage at $1 200; but if it was entitled to more thant 125 horse-power he could not determine the damage, as there was no evidence submitted.

From this decision of the auditor the town of Middleboro appealed.

Mr. Freeman C. Coffin had been the engineer for the city of Taunton, and for four years made gagings on that stream, one year before the dam was built and three years afterward. His gagings showed that more water went down stream during the dry months after the dam was built than before. After Mr. Coffin's death the city of Taunton employed Mr. Metcalf as its engineer. There was a trial before a jury in Brockton in November, 1907, and the jury awarded the town $12,000 damages. That, of course, includes interest, so the verdict would be about seven thousand dollars, and interest.

Judge King, of Springfield, presided, and he cut the verdict down

to $3 500, or he said that he would set the verdict aside unless the town of Middleboro would accept $3 500, which they refused to do. Within the last two weeks the case has again been tried and the jury awarded $13 241.50, about seventy-five hundred dollars and interest. A motion is being argued to-day to set that verdict aside. The case will undoubtedly go to the Supreme Court.

We take about two million gallons per day. That means 2.6 horse-power at this mill. When we first began we took about 1.5 horse-power. Mr. Coffin testified that the city of Taunton could take 10 000 000 gallons per day and still give the town of Middleboro during the dry months as much water as it had before we built the dam.

At the trial before the auditor, Mr. Allen, of Worcester, was the expert engineer for the town of Middleboro, and it then seemed to be the policy of the town to make out as large as possible the amount of water carried by the stream, and that we took all the water that they didn't get. At the last trial they changed their tactics and made the amount of flow of stream as small as possible.

Mr. Leonard Metcalf. Mr. King has set the facts admirably before you, but there is perhaps one other point to which I may call attention. I might say that of this 2½ feet in depth in storage over the ponds, the present consumption would correspond to from three to six inches, depending upon what ponds were included in the storage. There is an obligation in the taking of water from certain of the ponds by New Bedford as to the erection of weirs between the ponds, which results in limiting the flow, or determining the direction of the flow, at certain seasons of the year.

Furthermore, it may be of interest to add that it was estimated that the available power at this privilege was about seventy-five horse-power. At the time of the diversion, as Mr. King has stated, the diversion was about one and a half horse-power, and at the present time it is about two and six-tenths horse-power. The real estate experts put on by the town of Middleboro testified that the value of the entire plant, including the entire physical plant and its business as a going concern, the wires, dynamos, machinery, and so on, was $70 000, and that it had cost, I think, $63 000 as matter of fact about eight months before. In spite of that fact, the jury awarded the sum which Mr. King has stated for a diversion at that time of 1½ horse-power out of 75. The $63 000 included a gas plant also, — a mere trifle.

Of course it seems very unjust from the point of view of equity, because as actually operated they are undoubtedly getting much more power to-day from that privilege with the water which is let down from storage during the dry months than they did before the construction of the dam, but the plaintiff laid great stress on the fact that the control of that storage was within the hands of Taunton. Of course it would be impossible for Taunton to hold this water up indefinitely; it has got to come down some time, and from a practical point of view it does not seem probable that Taunton would hold it up during the dry season to let it down in the wet season and encourage litigation. Compensation in kind, or compensation in storage of water, does not seem to have worked in this case.

APPENDIX 5

REFERENCES

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REFERENCES
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